



Human Biomolecular Atlas Program (HuBMAP)



Katy Börner Indiana University (HIVE-IU)

Jeff Spraggins Vanderbilt University (TMC-VU)

dkNET Webinar Series

Oct 14, 2022

Vision

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



HuBMAP

The Human BioMolecular Atlas Program

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

ACCELERATE TOOLS AND TECHNIQUE DEVELOPMENT

Accelerating the development of the next generation of tools and techniques for constructing high resolution spatial tissue maps that quantify multiple types of biomolecules either sequentially or simultaneously



GENERATE 3D HUMAN TISSUE MAPS

Generating foundational 3D human tissue maps using validated high-content, high-throughput imaging and omics assays



ESTABLISH OPEN DATA PLATFORM

Establishing an open data platform that will develop novel approaches to integrating, visualizing and modelling imaging and omics data to build multi-dimensional tissue maps, and making data rapidly findable, accessible, interoperable, and reusable by the global research community

COLLABORATE WITH THE RESEARCH COMMUNITY

Coordinating and collaborating with other funding agencies, programs, and the biomedical research community to build the framework and tools for mapping the human body at single cell resolution



SUPPORT PILOT PROJECTS

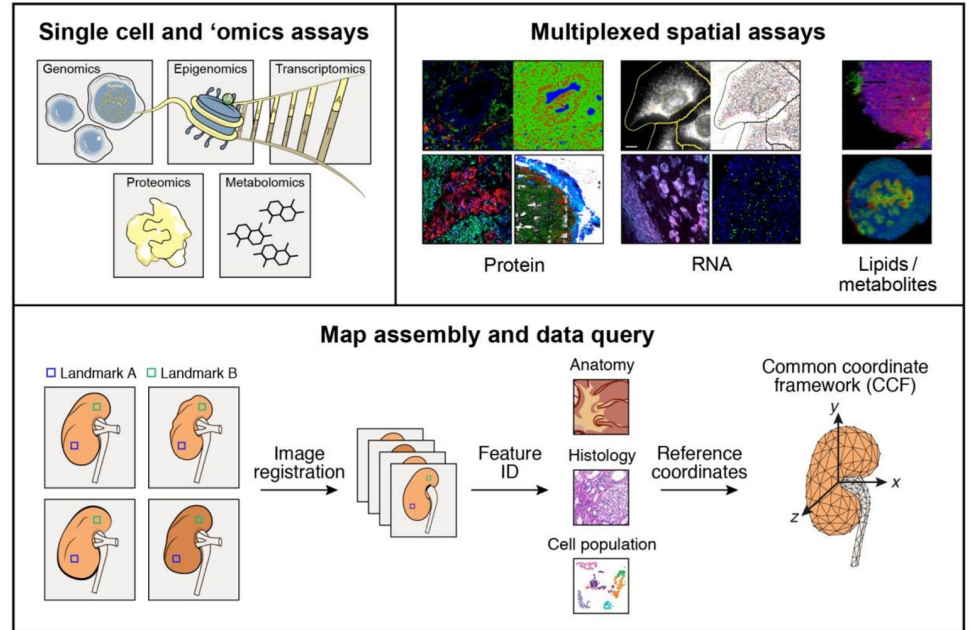
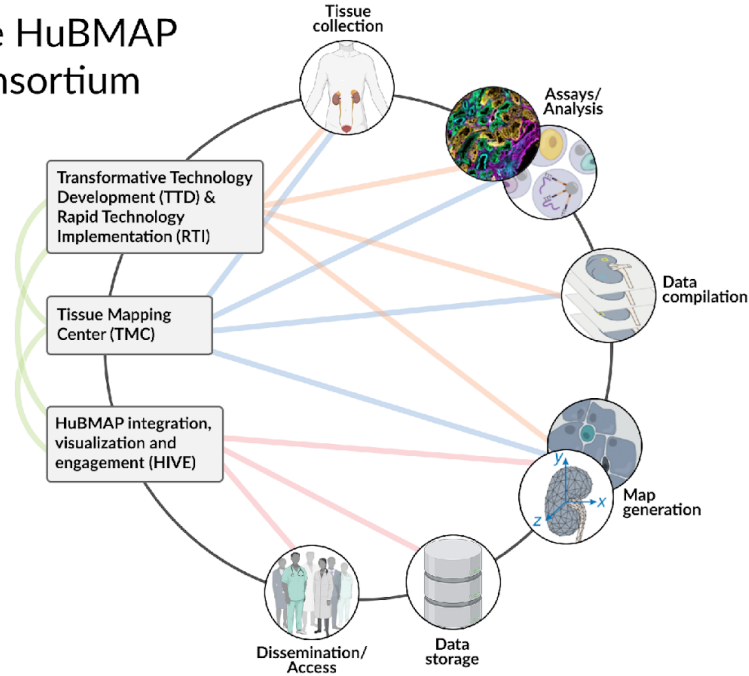
Supporting pilot projects that demonstrate the value of the resources developed by the program to study normal individual variations and tissue changes across the lifespan and the health-disease continuum



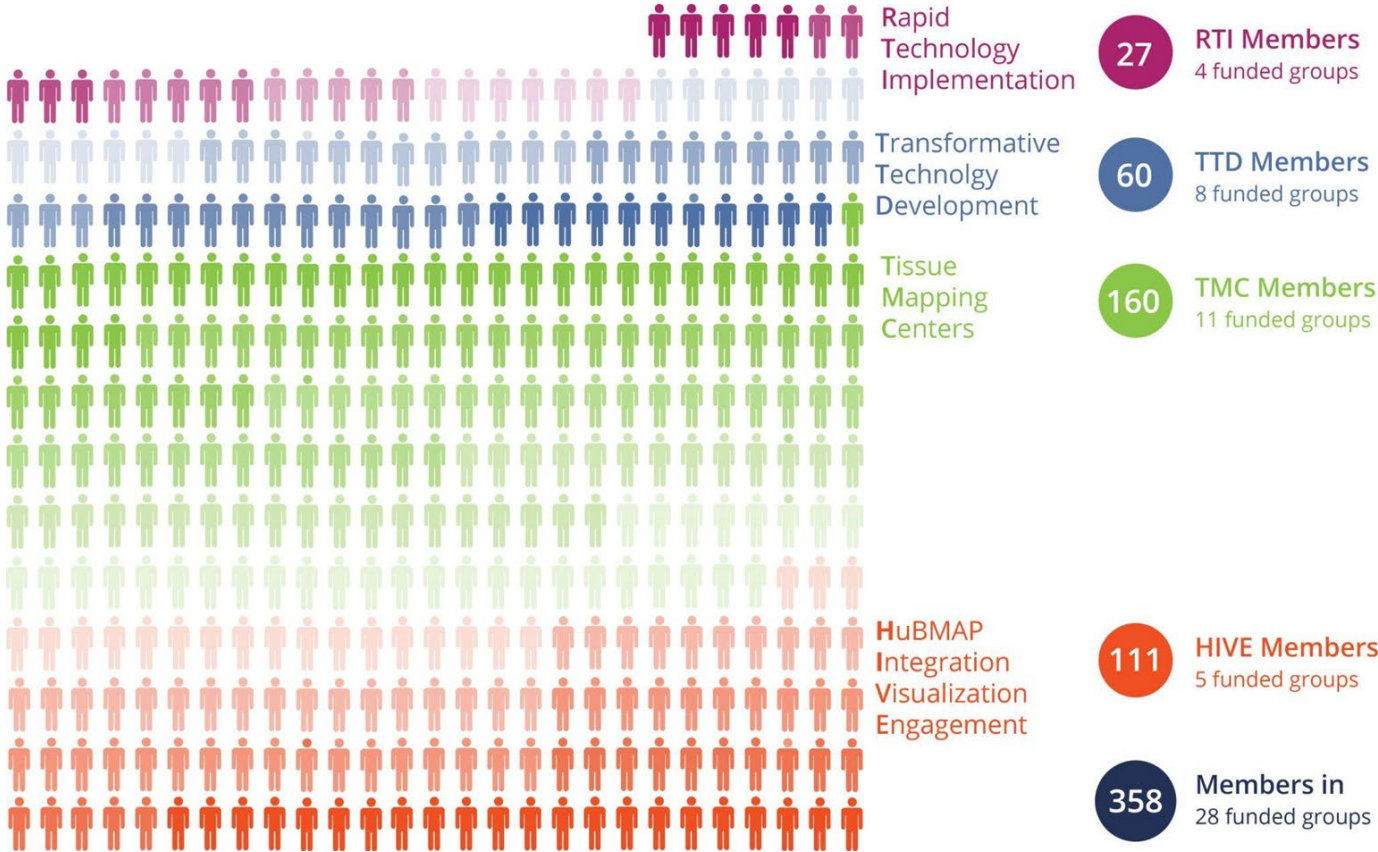
The Human Body at Cellular Resolution: The NIH Human Biomolecular Atlas Program

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

The HuBMAP Consortium



HuBMAP Funded Groups 2022



HuBMAP Contributing Sites

TMC, TTD
University of Washington
Pacific Northwest National Lab

RTI, TTD
Northwestern University

TMC
University of Iowa

HIVE - Mapping, RTI
New York Genome Center
GE Global Research
University of Rochester

NIH
Common Fund

TMC
Washington University, St. Louis
Washington University School of Medicine

TTD
Marquette University

 **SWITZERLAND**

TMC
University of Zurich

HIVE - Mapping, TTD
Indiana University
Purdue University

HIVE - Tools, TTD, RTI, TMC
Harvard University, Medical School
Broad Institute
Dana Farber Institute
Columbia University
Children's Hospital of Boston

 **NETHERLANDS**

TMC
Delft University of Technology

TMC, TTD
University of Connecticut
Yale University

HIVE - IEC, HIVE - Tools, RTI, TMC, TTD
Carnegie Mellon University
Pittsburgh Supercomputing Center
University of Pittsburgh
National Disease Research Interchange
Children's Hospital of Philadelphia
University of Pennsylvania
Pennsylvania State University

 **UNITED KINGDOM**

TMC, TTD, RTI, HIVE - TC
Stanford University,
University of California, Santa Cruz
University of California San Diego
California Institute of Technology
City of Hope National Medical Center

TMC
Vanderbilt University

TMC
University of Alabama, Birmingham

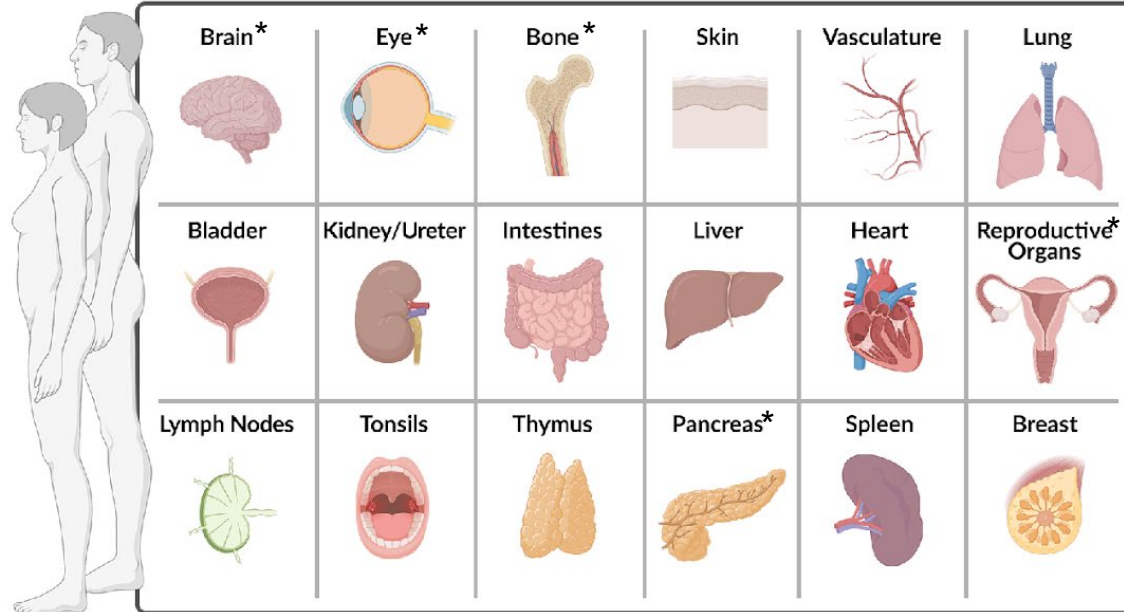
TMC
University of North Carolina, Chapel Hill

TMC
Texas Advanced Computing Center

TMC
University of Florida

HIVE - Tools, TMC
European Bioinformatics Institute
Wellcome Sanger Institute

Organ Specific Projects



* Newly added organs

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

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

Setup and Scale Up Phase (2018-2022)

Tool Development

- Standardized Analytical Workflows, Metadata, Protocols
- Multimodal/Multi-scale data generation

3D Maps and Reference Datasets

- HRA Common Coordinate Framework
- ASCT+B & 3D Reference Object Library
- Azimuth

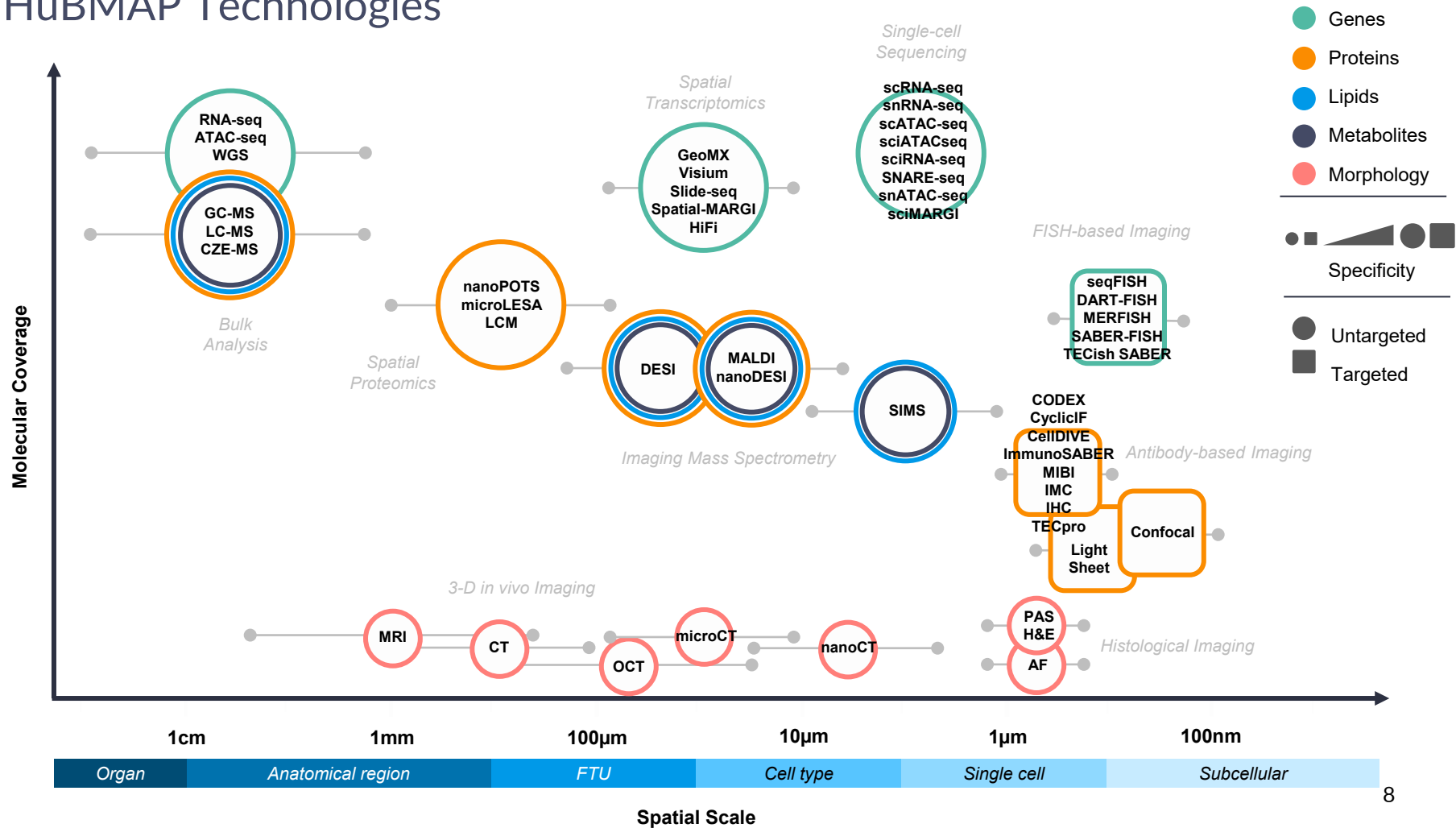
Open Data Platform

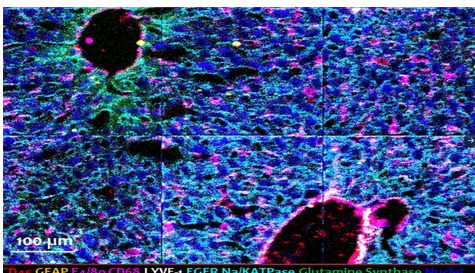
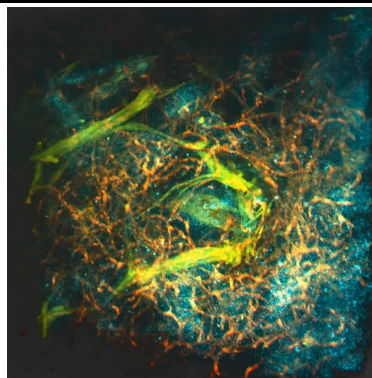
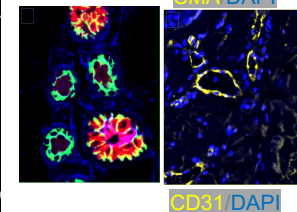
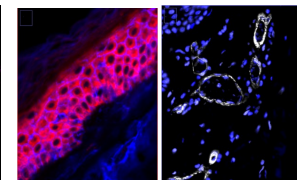
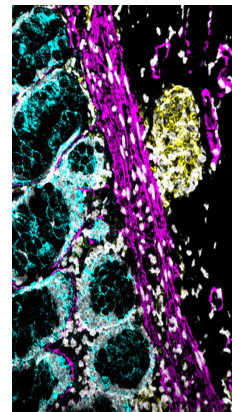
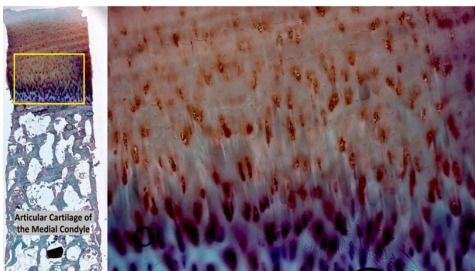
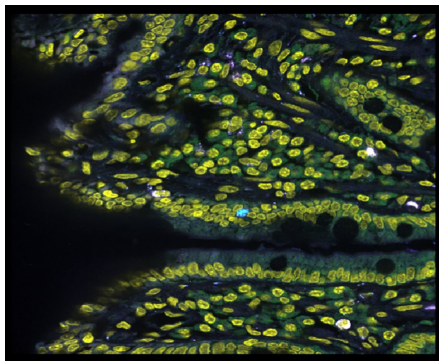
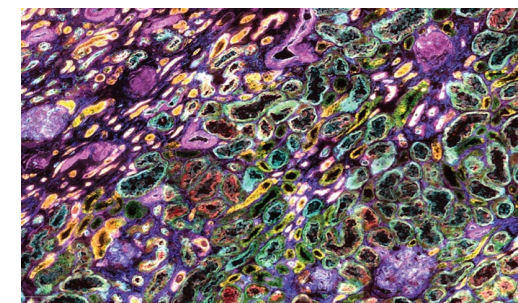
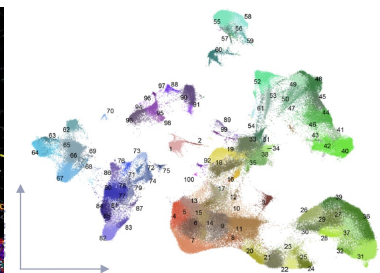
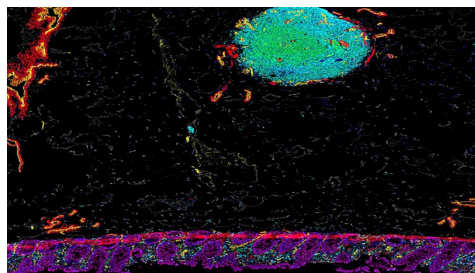
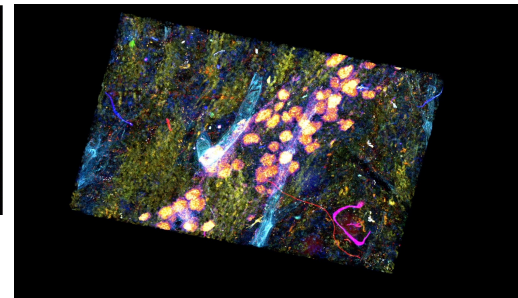
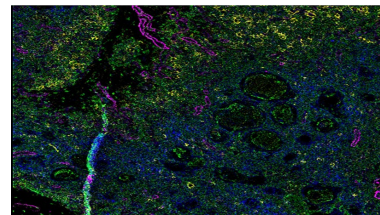
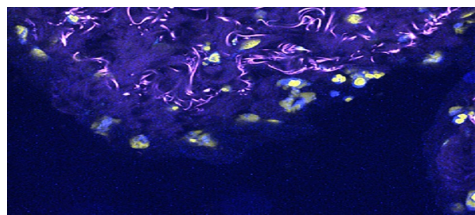
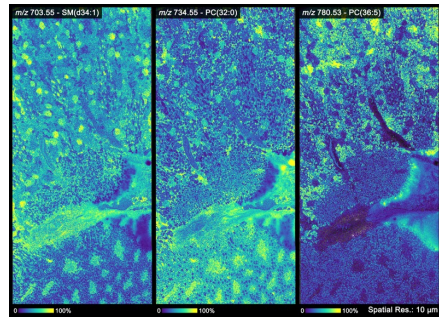
- HuBMAP Portal

Outreach and Collaboration

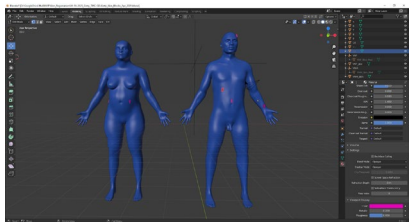
- Summer Internship Program, Jumpstart Program, Kaggle Competition

HuBMAP Technologies

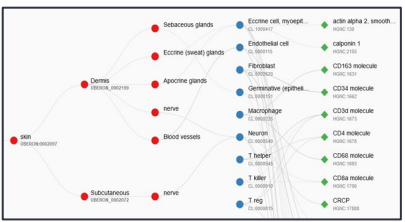




GE Research and U. Pittsburgh RTI: 3D reconstruction of multiplexed skin samples and spatial cell analysis



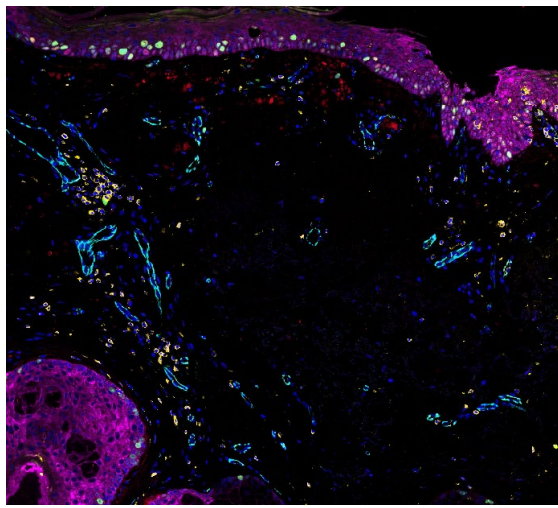
Registration of Skin Biopsy location using RUI



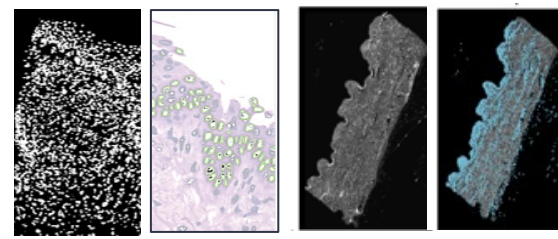
Registration of Skin Biomarkers in ASCT-B & OMAP



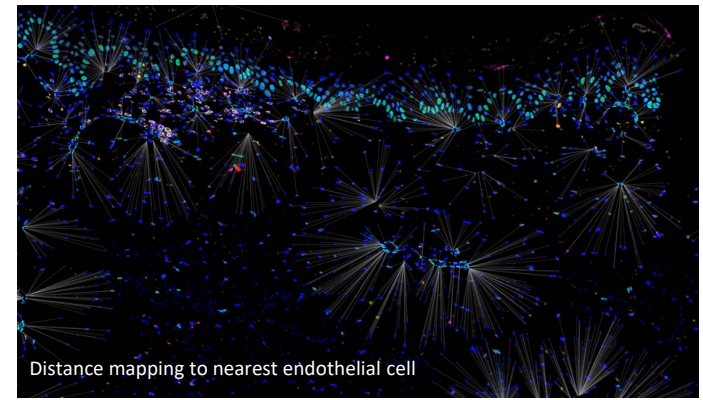
Tissue data collection: microCT imaging of skin FFPE blocks for multiplexed image 3D reconstruction



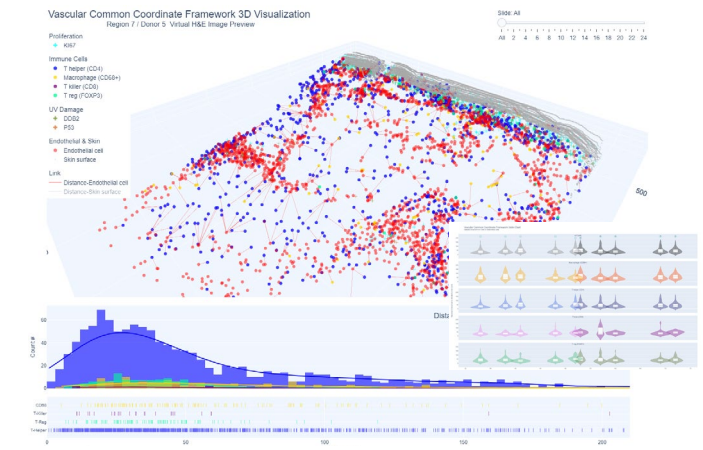
Multiplexed imaging of 18 skin biomarkers from 40 patients (Caucasian and African American)



Cell type classification (epithelial, immune, endothelial...) 3D Volume Reconstruction of 24 serial sections with micro CT as reference



Distance mapping to nearest endothelial cell

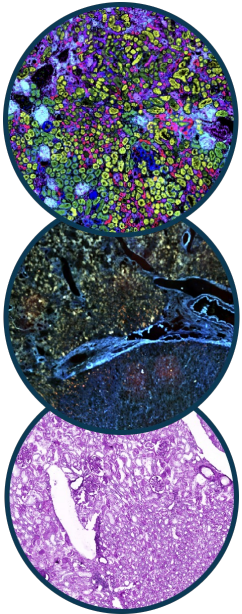


3D "Digital Twin" of skin cells and quantitative interactive spatial distances (Yingnan Ju and Katy Börner, IU)

Vanderbilt TMC Highlight

MULTIMODAL IMAGING MASS SPECTROMETRY

Discovery of important biomarkers, cell types, and tissue neighborhoods



MALDI Imaging Mass Spectrometry

- Provides molecular images of many molecular classes without the need for any stain or antibody.

Autofluorescence Microscopy

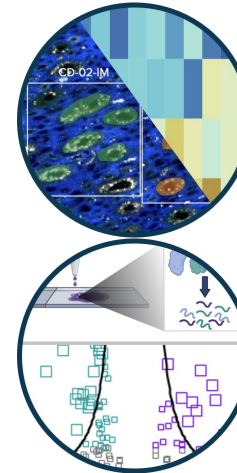
- An image type we can collect from every sample that is used for analysis and connecting data sets.

Stained Microscopy

- A common image type that can be used by pathologists to assess the tissue and identify important tissue regions.

SPATIALLY TARGETED MULTI-OMICS

Uncovers important pathways and mechanisms in regions discovered by Multimodal Imaging



Spatial Transcriptomics

- Gives a snapshot of the RNA transcript expression from defined tissue regions and cell types.

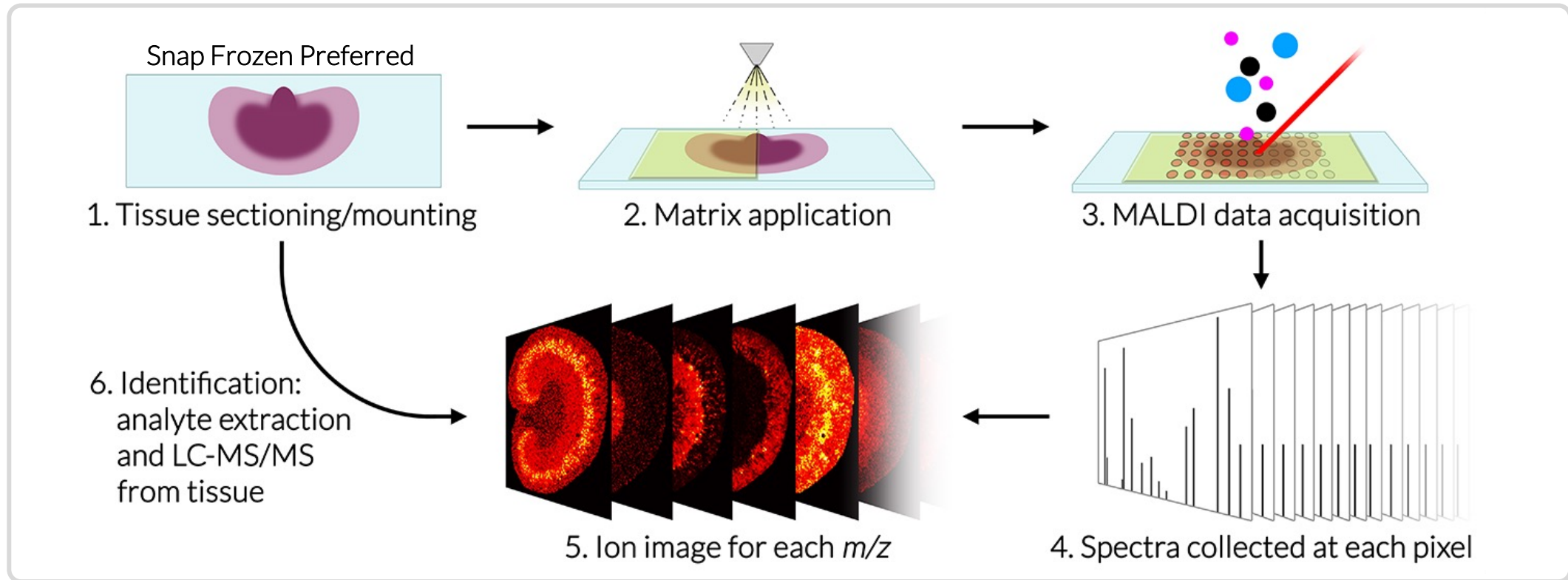
Spatial Proteomics

- Provides protein identification and abundance information from defined tissue regions and cell types.

We provide means of exploring the molecular content of human tissue in a fully open-ended way, without the need to know beforehand what we're looking for. The means for discovery we contribute to KPMP makes it possible to go look for completely new and previously unknown biochemical mechanisms behind kidney disease and can help find molecular targets for predicting, diagnosing, and mitigating disease.

Multimodal Imaging Mass Spectrometry

MALDI IMAGING MS / Overview



MALDI Imaging Mass Spectrometry offers untargeted, highly multiplexed molecular imaging of a wide variety of molecular classes at cellular resolution.

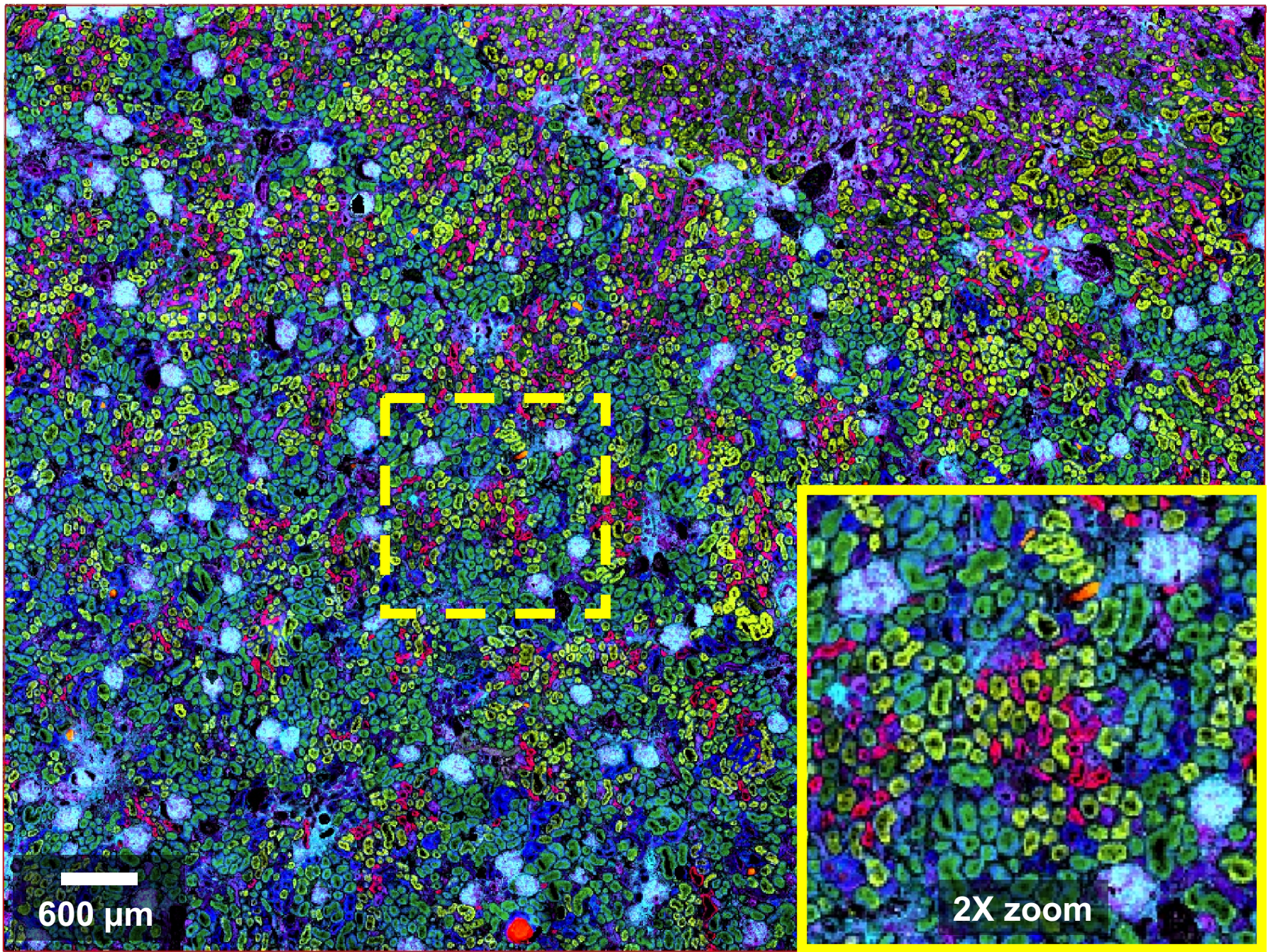
MALDI IMS

EXAMPLE DATA

10 μm MALDI IMS

Human kidney
MALDI timsTOF Flex
Negative Ion mode

- PE(O-38:5)
- PS(18:0_18:1)
- PS(18:0_20:4)
- SM4(d18:1_h24:0)
- SM3(d18:1_22:0)
- CL(72:8)



Kate Djambazova (VU)
Martin Dufresne (VU)

Multimodal Imaging Mass Spectrometry

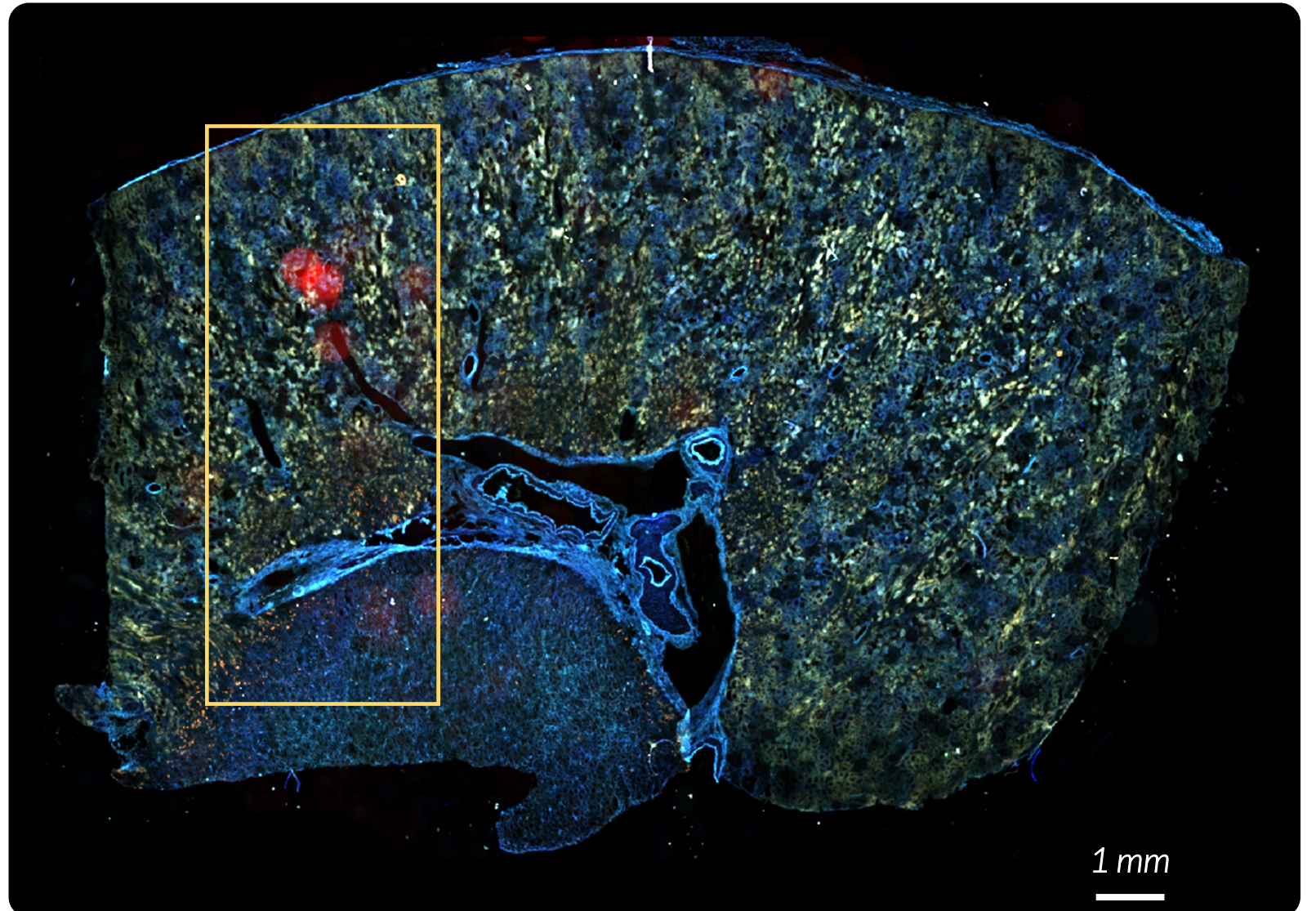
EXAMPLE DATA

Modalities

- (1) Autofluorescence Microscopy
 - Unstained fluorescence imaging used for image segmentation.
- (2) MALDI Imaging Mass Spectrometry
 - Unstained fluorescence imaging used for image segmentation.
- (3) PAS-Stained Microscopy
 - Tissue morphology/assessment

Sample Details

Human Kidney Tissue
38 yr Old Female
Left Kidney / Lower Pole
Cryosectioned at 10 μm
Matrix: 1,5-Diaminonaphthalene (DAN)
Matrix Application: TM-Sprayer (HTX)

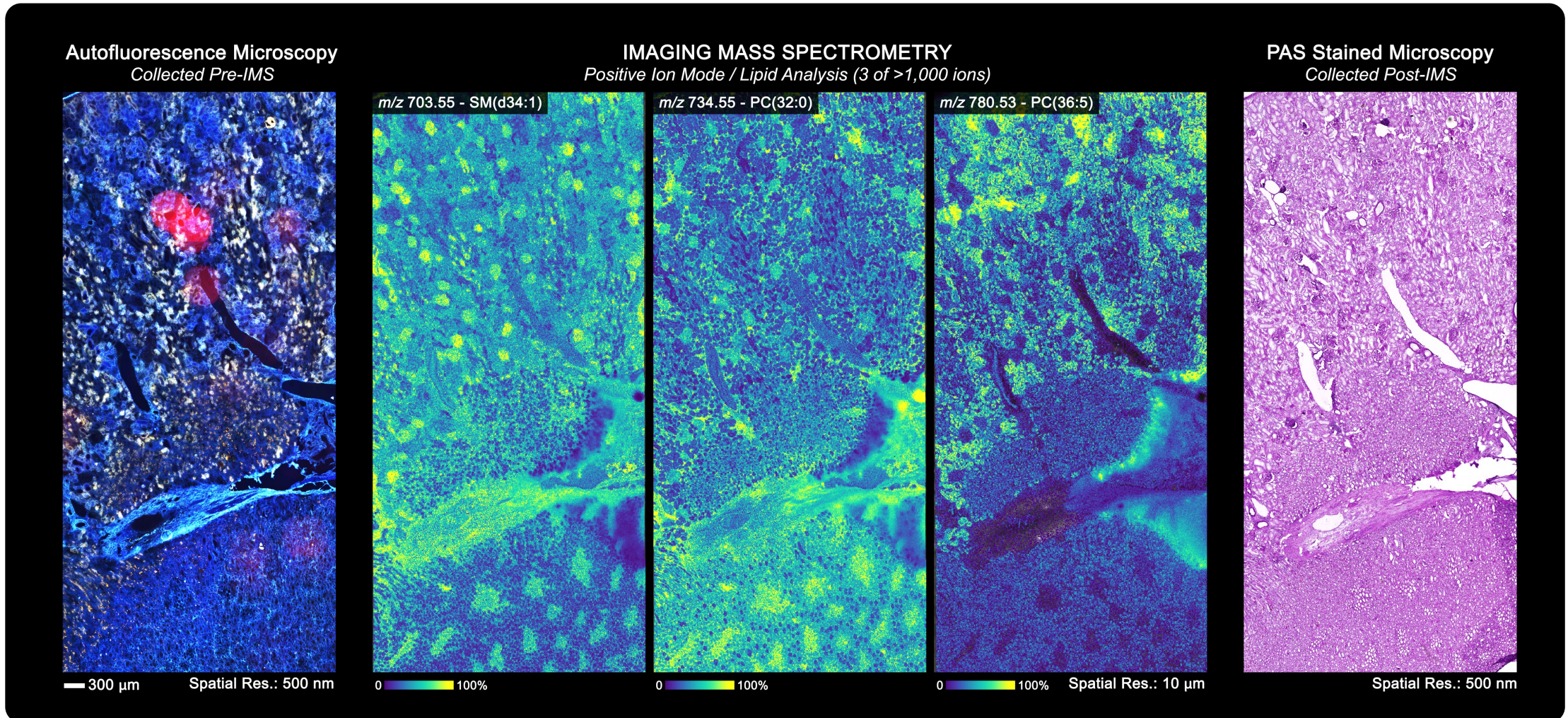


Multimodal Imaging Mass Spectrometry

Kate Djambazova (VU)

EXAMPLE DATA

Human Kidney



Multimodal Imaging Mass Spectrometry

FUNCTIONAL TISSUE UNIT SEGMENTATION

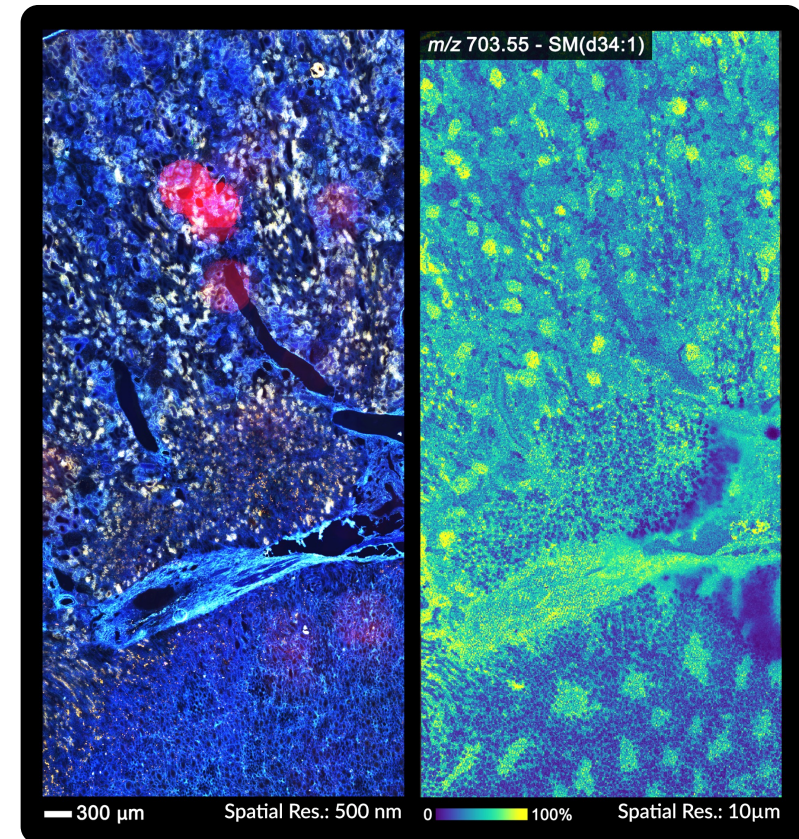
Multimodal imaging enables spatially-driven data mining and analysis of untargeted IMS data based on morphological features and functional tissue units by segmenting AF microscopy images.

MOTIVATION

- Want to segment FTUs like the glomerulus in tissue using microscopy in a reproducible way that is fully automated and compatible with any -omics technologies

SOLUTION

- Develop autofluorescence microscopy (AF) FTU segmentation
- Use co-registered stained and MxIF images to help with training data annotation
- Employ deep learning convolutional neural network approaches on whole slide images (WSIs)



Multimodal Imaging Mass Spectrometry

N. Heath Patterson (VU)

FUNCTIONAL TISSUE UNIT SEGMENTATION

Rapid segmentation model development

Annotate 4-8 IF images on 4 tiles for each FTU

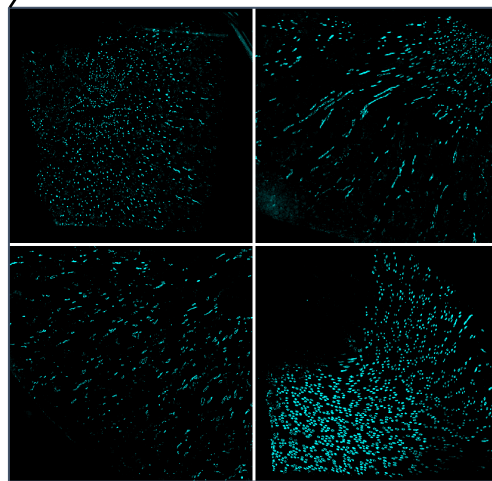
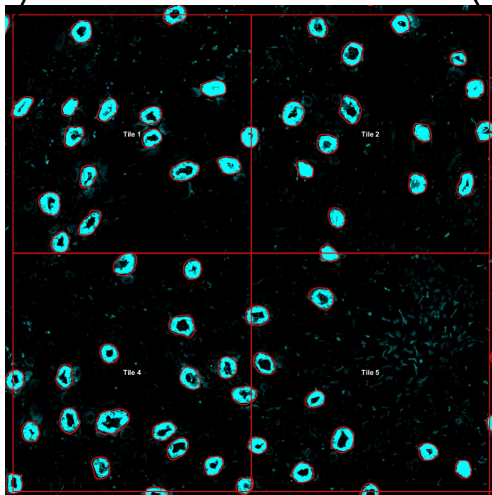
Train FTU detector using small IF dataset and segment all IF whole slide images

Curate full dataset on **confident IF segmentations**

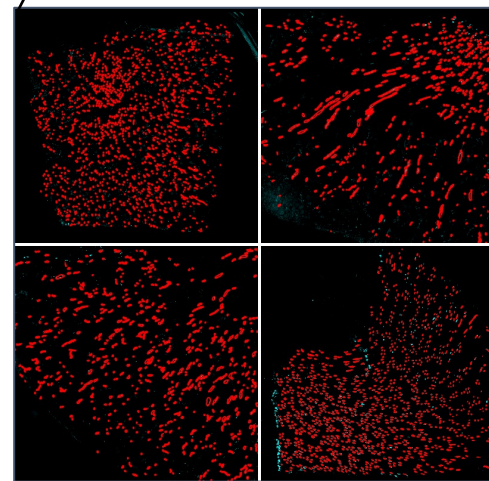
Transfer **annotations** to AF

Transfer learning of CNNs models on 1000s of instances per FTU using AF data

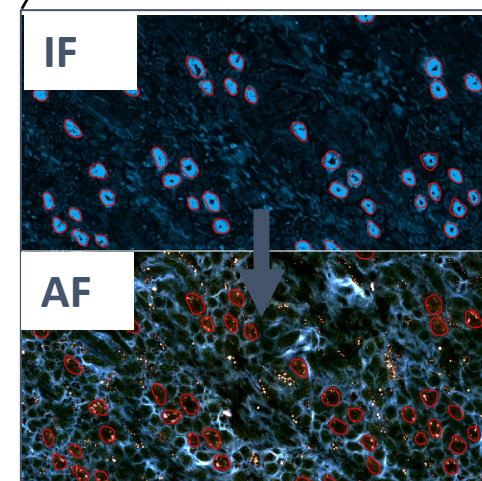
Label-free microscopic instance segmentation of FTUs on whole slide images



Whole slide images

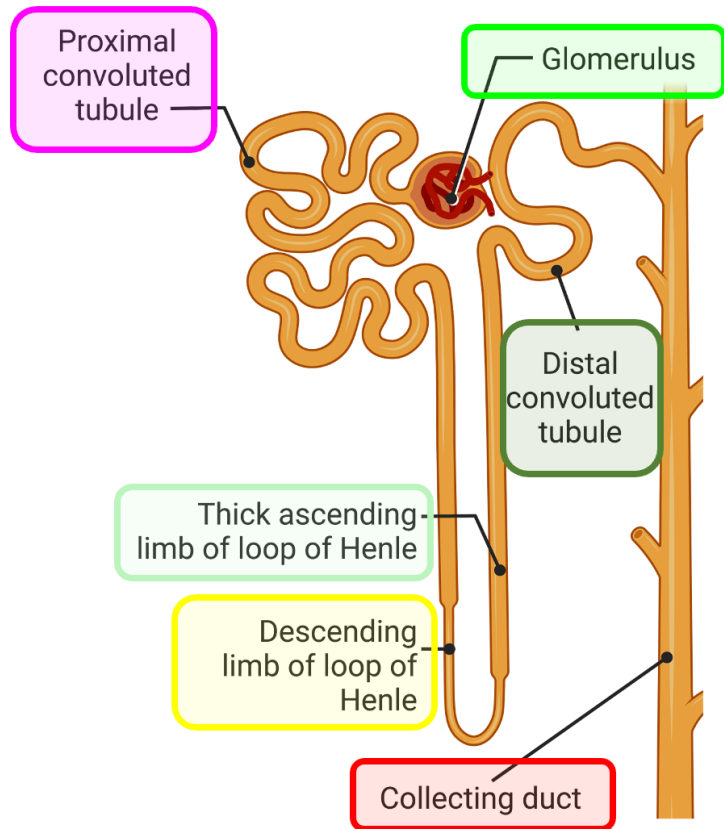


Whole slide images

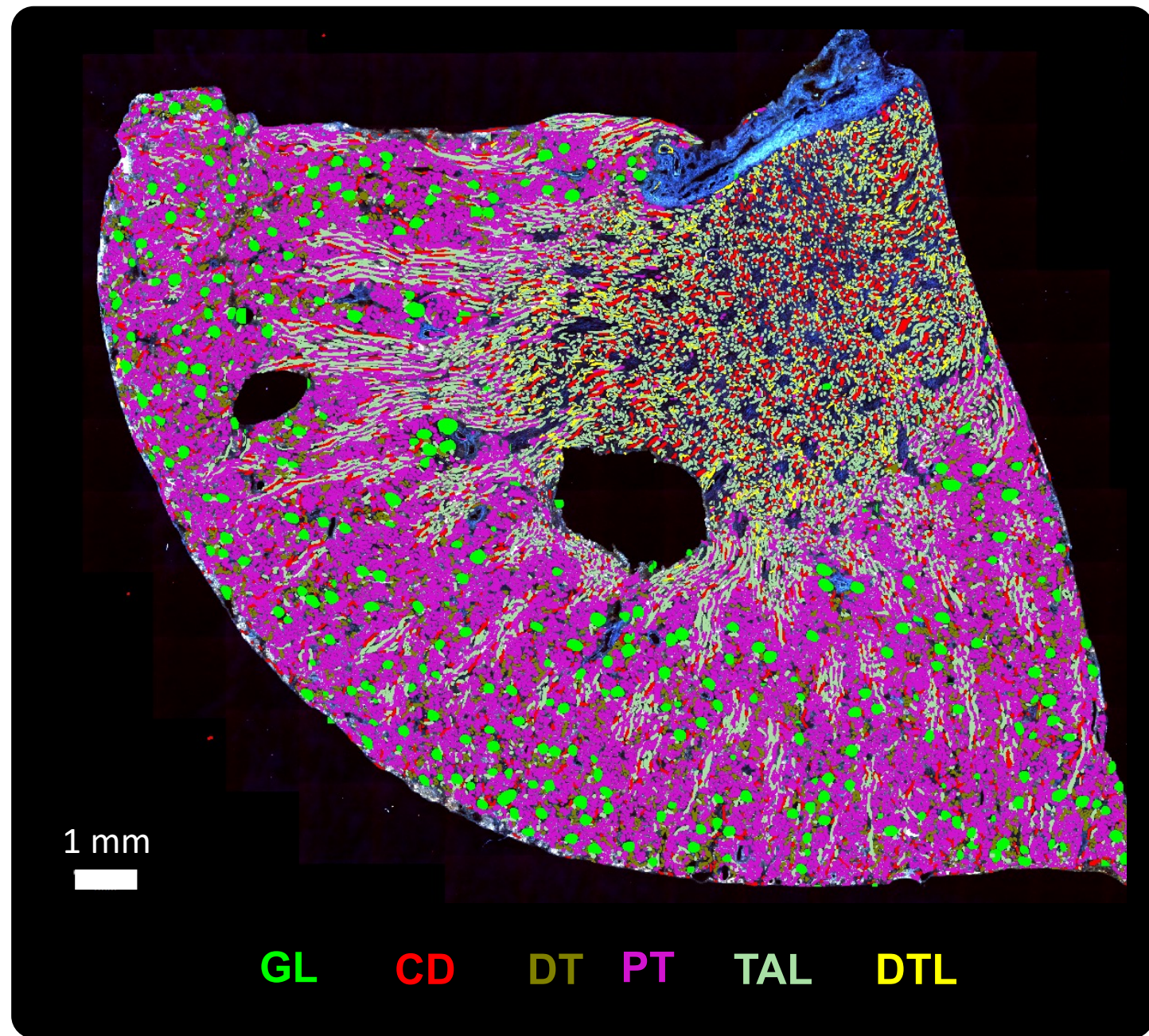


FTU Segmentation Map

Unlabeled AF Microscopy



N. Heath Patterson (VU)



Multimodal Imaging Mass Spectrometry

N. Heath Patterson (VU)
Martin Dufresne (VU)

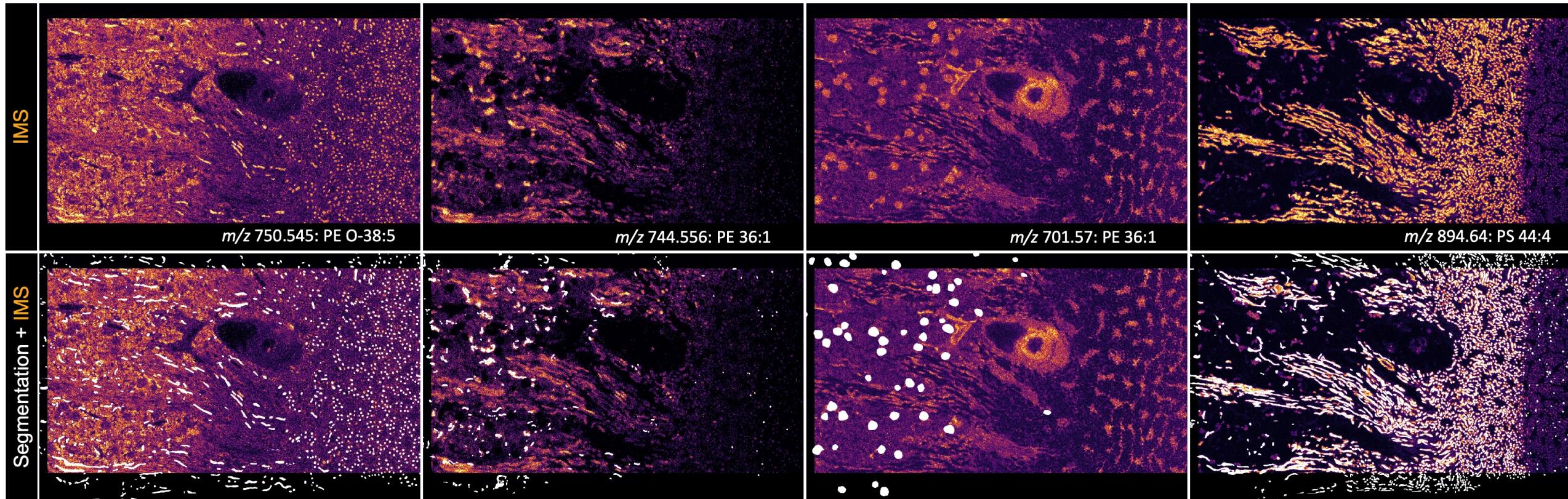
DATA INTEGRATION & MINING

Collecting Ducts

Distal Tubules

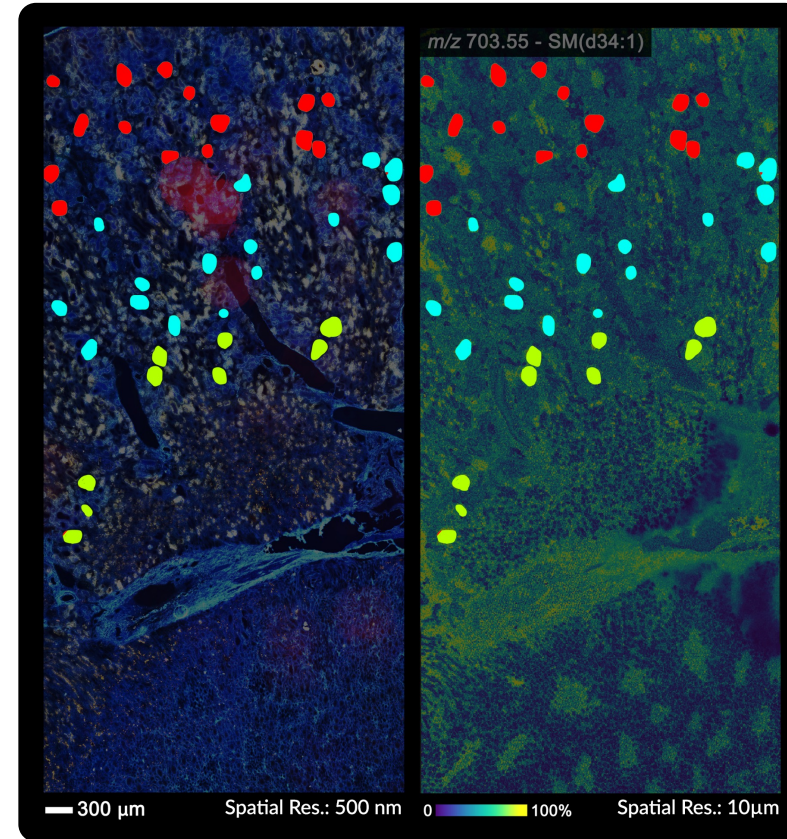
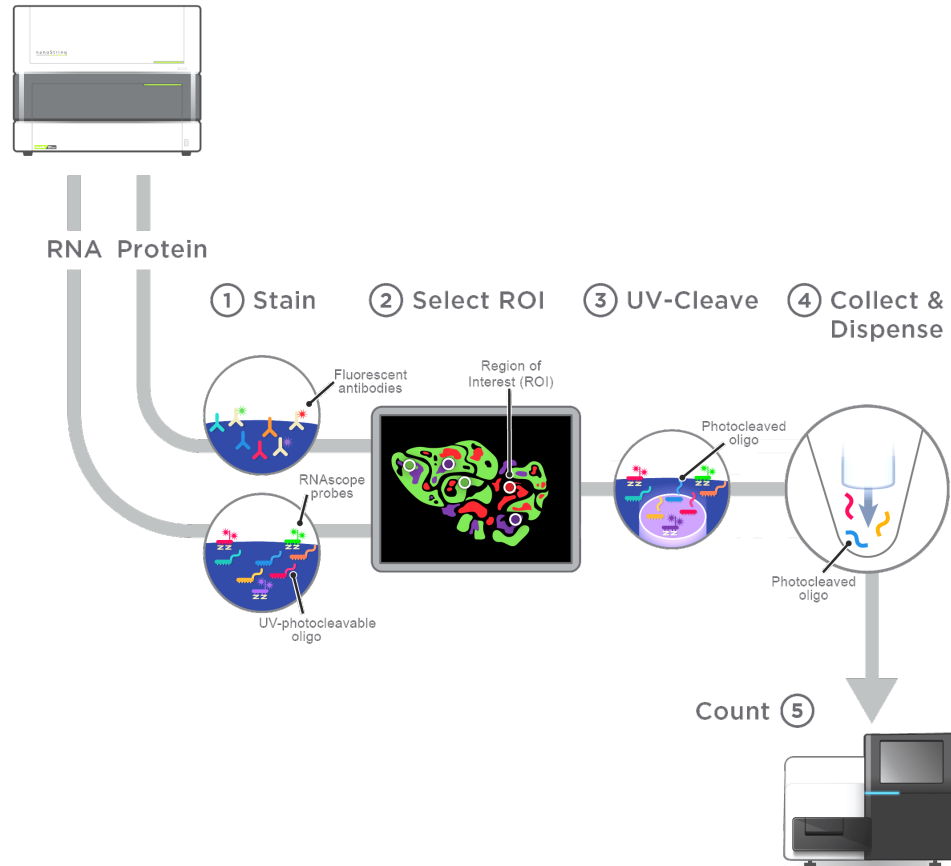
Glomeruli

Thick Ascending Limb



nanoString GeoMx Spatial Transcriptomics

DSP Overview

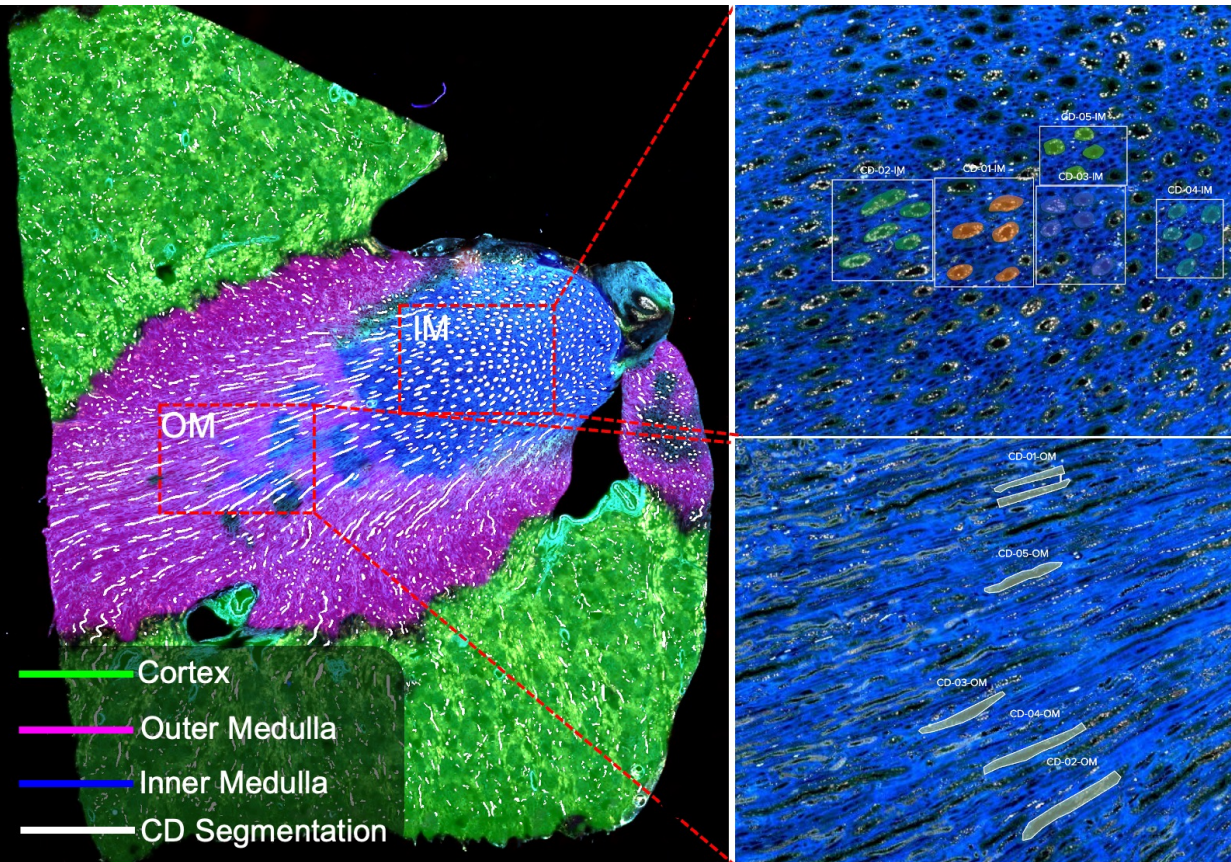


Our pipeline utilizes Multimodal Imaging Mass Spectrometry outputs to define important ROIs to drive the GeoMx Digital Spatial Profiler providing transcriptomics information for important FTUs, cell types, and neighborhoods.

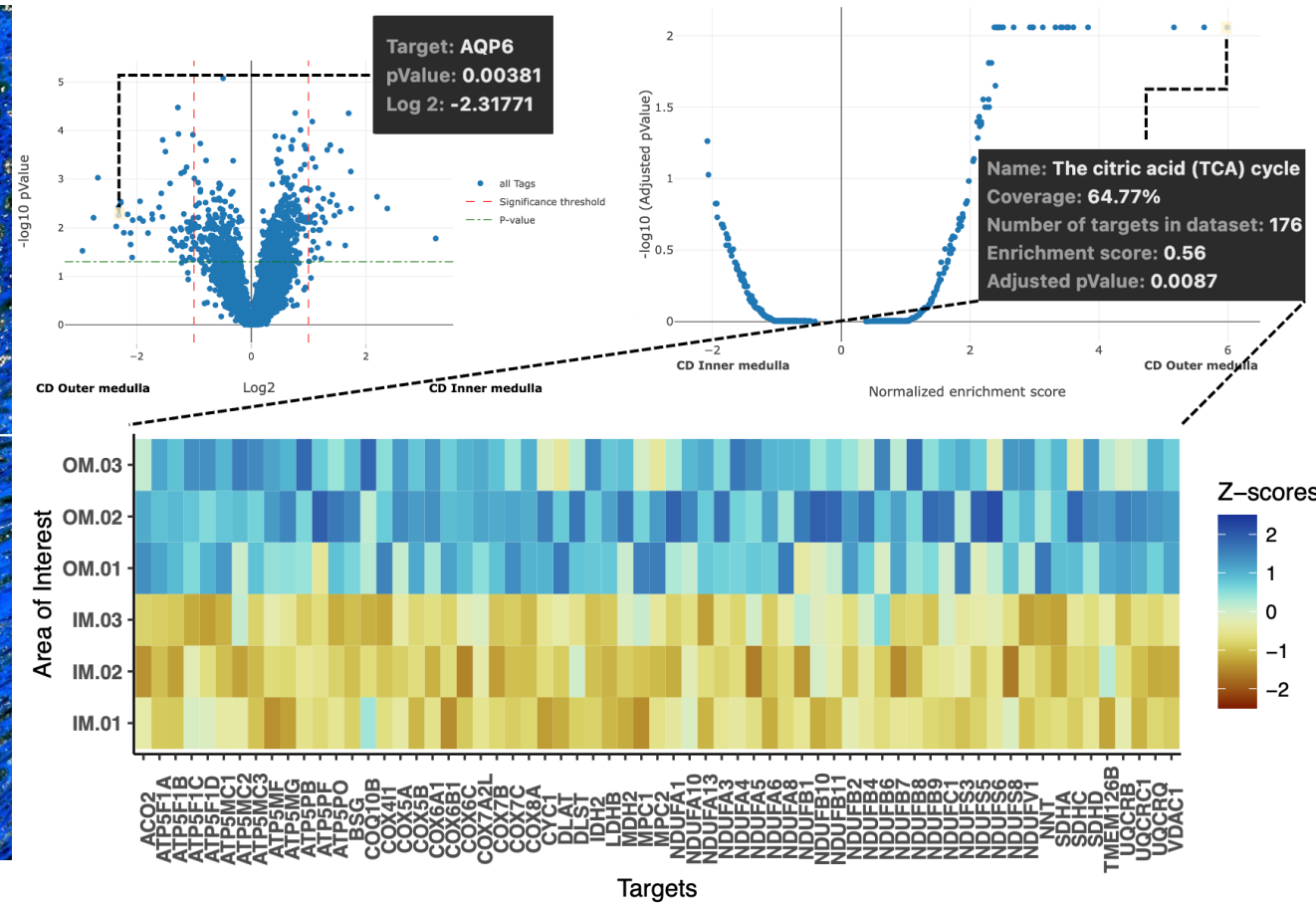
nanoString GeoMx Spatial Transcriptomics

EXAMPLE DATA


AF-Based Image Segmentation and ROI Selection



Comparison of Collecting Ducts from Inner and Outer Medulla



Human BioMolecular Atlas Program (HuBMAP) Method Development Community / Publications



Human Bio...
National Institutes of Health

Imaging Mass Spectrometry, molecular imaging, multimodal imaging, immunofluorescence microscopy, multiomics, single cell transcriptomics, chromatin accessibility assays, seqFISH, imaging mass cytometry, Multiphoton imaging, wide field confocal fluorescence microscopy, stochastic optical reconstruction microscopy, lightsheet CLARITY, ExPath, CARDFISH, MERFISH, Genomics, scRNAseq, 3-D imaging, autofluorescence microscopy, sci-RNAseq, sci-ATACseq, CODEX, kidney, spleen, thymus, lymph nodes, heart, lung, bowel, colon. **Show less**

- Workspace folder
- Workspace settings
- Tasks
- Manage reagents
- Administration
- New

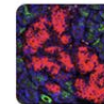
Timeline About Publications **181** Members **110** Discussions **15** Resources News

GeoMX Digital Spatial Profiler Whole Transcriptome Assay for Human Pancreas

Ann Fu¹, Yanping Zhang¹, Heather Kates¹, Jing Chen¹, Alberto Riva¹, Clayton E Mathews¹, Martha Campbell-Thompson¹
¹University of Florida



Martha Campbell-Thompson
Jun 27, 2022 · 👁 101



Immunohistochemistry of liver tissue sections

Presha Rajbhandari¹, Taruna V. Neelakantan¹, Brent R. Stockwell¹
¹Columbia University



Presha Rajbhandari
Jun 24, 2022 · 👁 65

Workflow for human

Scott Lindsay-Hewett¹, Va
¹University of California, San D



Scott Lindsay-Hewett
Jun 17, 2022 · 👁 10

Human Pancreas Pr

Jing Chen¹, Edward J But
¹University of Florida

Mowei Zhou / Publications / Top Down Proteomics Data Collection for Microdissected Kidney Tissue Functional Units

- Liquid chromatography (LC) meth...
- Mass spectrometer (MS) method ...
- Instrument Quality Control (QC) an...
- Data collection and QC Metric
- Quality Assurance (QA) of HubMA...



Top Down Proteomics Data Collection for Microdissected Kidney Tissue Functional Units

James M Fulcher¹, Isaac Kwame Attah², Mowei Zhou², Ljiljana.PasaTolic²
¹Pacific Northwest National lab; ²Pacific Northwest National Laboratory

Sep 01, 2022

Run

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In Development Share dx.doi.org/10.17504/protocols.io.rm7vzy5e5lx1/v1

Human BioMolecular Atlas Program (HuBMAP) Method Development Community PNNL-T

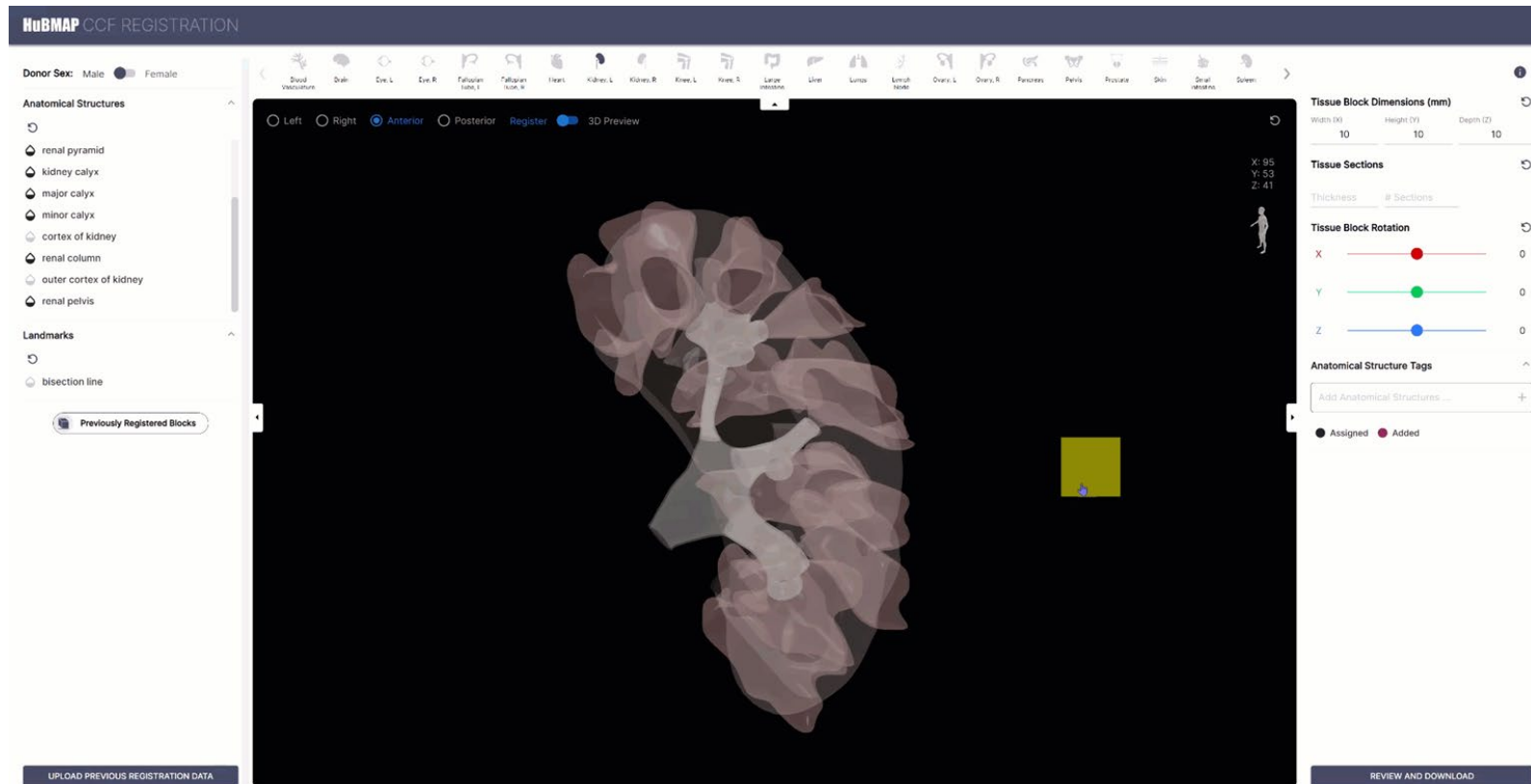
Mowei Zhou
Pacific Northwest National Laboratory

Steps Materials Forks Metadata References Metrics

ABSTRACT

The protocol describes how to use laser capture microdissection (LCM) to cut small regions (300 μm) from tissue sections. This is followed by top down proteomics analysis by liquid chromatography mass spectrometry (LC-MS).

CCF Registration User Interface (RUI)



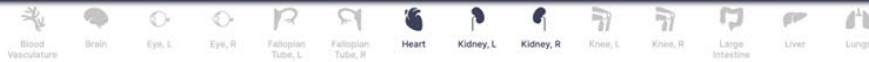
<https://hubmapconsortium.github.io/ccf-ui/rui/>

CCF Exploration User Interface (EUI)

HuBMAP CCF EXPLORATION

LOGIN

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

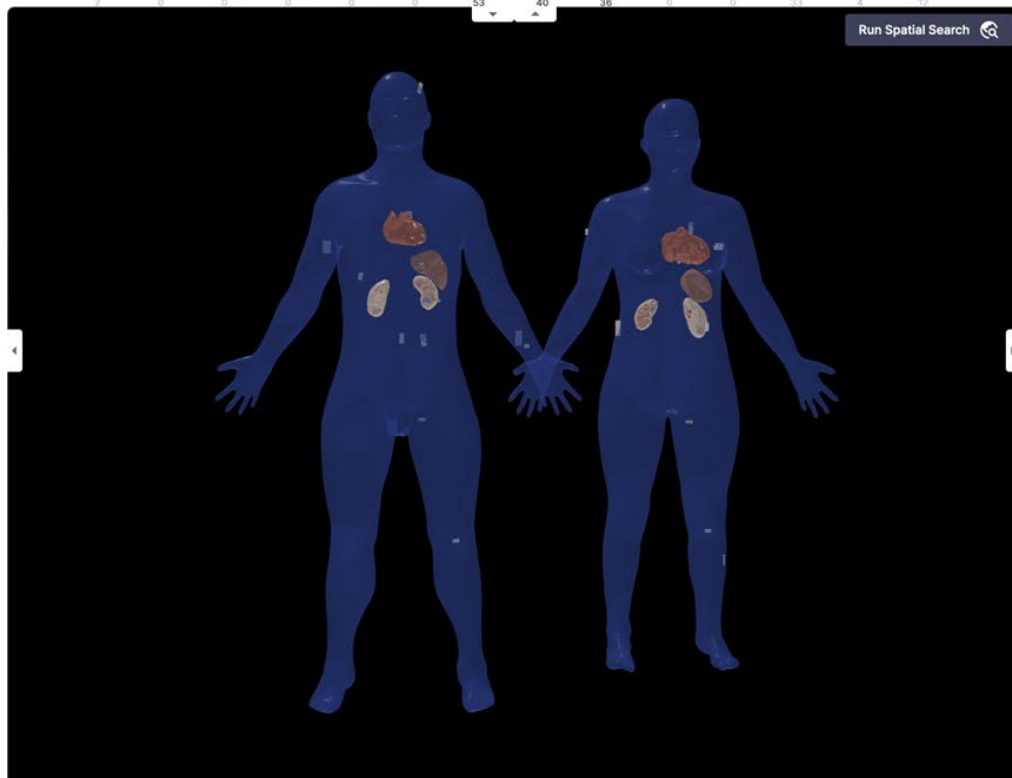


Search anatomical structures...

body	377
brain	0
lymph node	33
eye	0
fallopian tube	0
heart	53
kidney	76
knee	0
liver	4
lung	11
ovary	1
pancreas	4
pelvis	0

Search cell types...

cell	377
absorptive	43
adventitial stromal cell	67
afferent neuron cell	4
airway deuterosomal cell	12
alveolar type 1 fibroblast	12
alveolar type 2 fibroblast	12
amnion mesenchymal stromal cell (amsc)	0
apocrine cell	33
articular chondrocyte	0
astro il1 fgfr3 serpin12 primary motor cortex	0
astro il-6 fgfr3 aqp1 primary motor cortex	0
astro il-6 fafr3 plca1 primary motor cortex	0



body | cell

9	Tissue Data Providers
146	Donors
377	Tissue Blocks
622	Tissue Sections
1286	Tissue Datasets

- Apical Septum Female
Entered 3/16/2021, Peter Hanna, SPARC/UCLA
- Basal Right Ventricle Free Wall Female
Entered 3/16/2021, Peter Hanna, SPARC/UCLA
- Basal Septum Left Ventricle Female
Entered 3/16/2021, Peter Hanna, SPARC/UCLA
- Basal Septum Left Ventricle Male
Entered 3/16/2021, Peter Hanna, SPARC/UCLA
- Left Ventricle Apex Female
Entered 3/16/2021, Peter Hanna, SPARC/UCLA
- Left Ventricle Apex Male
Entered 3/16/2021, Peter Hanna, SPARC/UCLA
- Middle Anterior Left Ventricle Female
Entered 3/16/2021, Peter Hanna, SPARC/UCLA
- Middle Anterior Left Ventricle Male
Entered 3/16/2021, Peter Hanna, SPARC/UCLA
- Middle Lateral Left Ventricle Female
Entered 3/16/2021, Peter Hanna, SPARC/UCLA
- Middle Lateral Left Ventricle Male
Entered 3/16/2021, Peter Hanna, SPARC/UCLA
- Middle posterior Left Ventricle Female
Entered 3/16/2021, Peter Hanna, SPARC/UCLA
- Apical Septum Male
Entered 3/16/2021, Peter Hanna, SPARC/UCLA
- Middle posterior Left Ventricle Male
Entered 3/16/2021, Peter Hanna, SPARC/UCLA
- Middle Septum Female
Entered 3/16/2021, Peter Hanna, SPARC/UCLA

<https://portal.hubmapconsortium.org/ccf-eui>

CCF Exploration User Interface (EUI)

HuBMAP CCF EXPLORATION

LOGIN

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



Search anatomical structures...

body	377
brain	0
lymph node	33
eye	0
fallopian tube	0
heart	53
kidney	76
knee	0
liver	4
lung	11
ovary	1
pancreas	4
pelvis	0

Search cell types...

cell	377
absorptive	43
adventitial stromal cell	67
afferent neuron cell	4
airway deuterosomal cell	12
alveolar type 1 fibroblast	12
alveolar type 2 fibroblast	12
amnion mesenchymal stromal cell (amsc)	0
apocrine cell	33
articular chondrocyte	0
astro I1 fgfr3 serpin12 primary motor cortex	0
astro I1-6 fgfr3 aqp1 primary motor cortex	0
astro I1-6 fafr3 plca1 primary motor cortex	0



body | cell

9	Tissue Data Providers
146	Donors
377	Tissue Blocks
622	Tissue Sections
1286	Tissue Datasets

Female, Age 44, BMI 28.0
Entered 12/26/2019, Jamie Allen, TMC-Vande... ^

Registered 6/10/2020, Jamie Allen, TMC-Van...
17 x 18 x 3 millimeter, 1.5 millimeter, fresh_fro...

0 |-----| 2

MALDI MALDI PAS AF P

Registered 12/27/2019, Jamie Allen, TMC-Van...
17 x 18 x 1.5 millimeter, 1.5 millimeter, fresh...

Registered 12/27/2019, Jamie Allen, TMC-Van...
17 x 18 x 1.5 millimeter, 1.5 millimeter, fresh...

Female, Age 44, BMI 28.0
Entered 12/26/2019, Jamie Allen, TMC-Vande... ^

Registered 6/10/2020, Jamie Allen, TMC-Van...
17 x 18 x 3 millimeter, 1.5 millimeter, fresh_fro...

0 |-----| 2

OTHER PAS PAS OTHER

Registered 11/10/2020, Jamie Allen, TMC-Van...
17 x 18 x 1.5 millimeter, 1.5 millimeter, fresh...

Registered 11/10/2020, Jamie Allen, TMC-Van...
17 x 18 x 1.5 millimeter, 1.5 millimeter, fresh...

Apical Septum Female
Entered 3/16/2021, Peter Hanna, SPARC/UCLA

Basal Right Ventricle Free Wall Female
Entered 3/16/2021, Peter Hanna, SPARC/UCLA

Basal Septum Left Ventricle Female

CCF Exploration User Interface (EUI) - Spatial Search

The image shows the 'Configure Spatial Search' interface. On the left, the configuration panel includes:

- Configure Spatial Search** (with an information icon)
- Donor Sex: **Female** Organ: **Kidney, L** Edit
- Probing Sphere Radius**: A slider set to **6 mm**. Below it are buttons for **Reset Probing Sphere** and **Reset Camera View**.
- 0 Tissue Blocks** (with an information icon)
- 0 Anatomical Structures** (with an information icon)
- 0 Predicted Cell Types from ASCT+B Tables** (with an information icon)
- Run Spatial Search** button at the bottom.

The main view on the right is a 3D visualization of a kidney model with a yellow probing sphere. It includes:

- Instruction: **Use the keyboard or click a Tissue Block to move the Probing Sphere**
- A smaller inset view of the kidney model.
- Keyboard controls: **Q** (blue), **W** (green), **E** (blue) in the top row; **A** (red), **S** (green), **D** (red) in the bottom row.
- Coordinates: **X: 65**, **Y: 38**, **Z: 39**.

CCF Exploration User Interface (EUI) & Vitessece

HuBMAP CCF EXPLORATION LOGIN

Open in Portal

HuBMAP Donors Samples Datasets Other Atlas & Tools Resources User Profile

HBM645.ZQSN.258 Kidney (Right) MALDI IMS

Sections

- Summary
- Visualization
- Provenance
- Metadata
- Files
- Collections
- Contributors
- Attribution

MALDI Imaging MS data collected from the Right Kidney of a 44 year old White Female donor by the Biomolecular Multimodal Imaging Center (BIOMIC) at Vanderbilt University. BIOMIC is a Tissue Mapping Center that is part of the NIH funded Human Biomolecular Atlas Program (HuBMAP). Mass Spectrometry images of Lipids were collected with a Bruker Daltonics MALDI timsTOF Flex Prototype at 10 m from m/z 100-2000 in Positive Ion Mode. Support was provided by the NIH Common Fund and National Institute of Diabetes and Digestive and Kidney Diseases (U54 DK120058). Tissue was collected through the Cooperative Human Tissue Network with support provided by the NIH National Cancer Institute (5 UMI CA183727-08).

Publication Date: 2020-09-08 Modification Date: 2022-02-11

Visualization

Spatial Layers x Spatial

- 700.564 CerP(d40) [checked]
- 701.512 PA(36:1)- [checked]
- 718.538 PE(34:0)- [checked]
- 707.501 PA(O-38:E) [checked]
- 700.564 CerP(d40) [unchecked]

Data Set x

- VAN0012-RK-103-75-IMS_NegMode_multilayer.ome.tif

body | cell

- 9 Tissue Data Providers
- 146 Donors
- 377 Tissue Blocks
- 622 Tissue Sections
- 1286 Tissue Datasets

Female, Age 44, BMI 28.0
Entered 12/26/2019, Jamie Allen, TMC-Vande...

- Registered 6/10/2020, Jamie Allen, TMC-Van... 17 x 18 x 3 millimeter, 1.5 millimeter, fresh...

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Apical Septum Female
Entered 3/16/2021, Peter Hanna, SPARC/UCLA

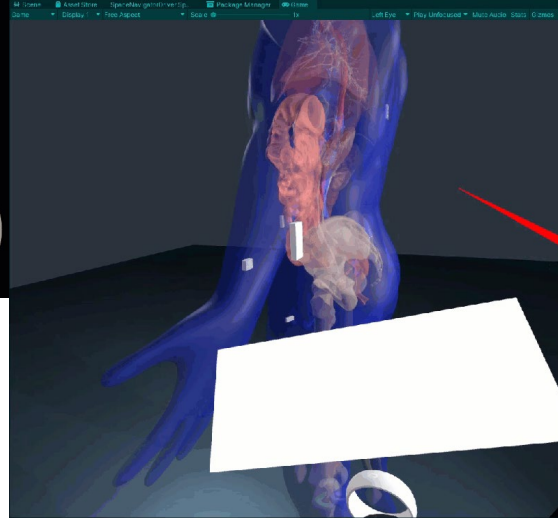
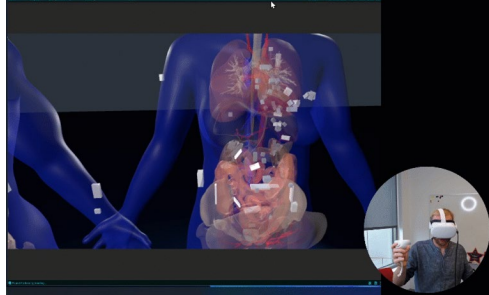
Basal Right Ventricle Free Wall Female
Entered 3/16/2021, Peter Hanna, SPARC/UCLA

Basal Septum Left Ventricle Female

<https://portal.hubmapconsortium.org/ccf-eui>

CCF VR Organ Gallery

- Immersive application to view, explore, and analyze 3D reference organs, anatomical structures, and cell types
- Preserves spatiality when displaying registered tissue blocks
- Embeds biological structure in 3D space
- Allows user to subset tissue blocks and cell type counts by clinical metadata (age, sex, BMI)
- Uses [CCF API](#) to retrieve up-to-date 3D organs and tissue blocks
- Interested in becoming a tester? Contact Andreas Bueckle at abueckle@iu.edu
- More info:
 - Preprint: [10.31219/osf.io/z9gm3](https://doi.org/10.31219/osf.io/z9gm3)
 - Research demo: <https://youtu.be/S9pBOISfsnc>



<https://hubmapconsortium.github.io/ccf/pages/ccf-gallery.html>

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).

They are ESSENTIAL for developing AS partonomies, CT typologies, and 3D reference objects across scales -- from body to functional tissue unit (FTU) to cell.

ASCT Table

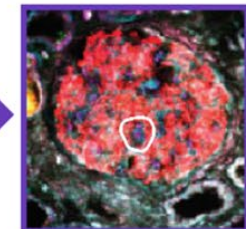
Structure/Region	Sub structure/Sub region	Cell Type
Renal Corpuscle	Bowman's (glomerular) Capsule/parietal layer	Parietal epithelial Cell
	Bowman's (glomerular) Capsule/visceral layer	Podocyte
	Glomerular Tuft	Capillary Endothelial Cell
		Mesangial Cell
Tubules	Proximal Tubule	Proximal Tubule Epithelial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

Ontology

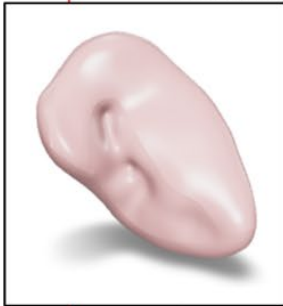
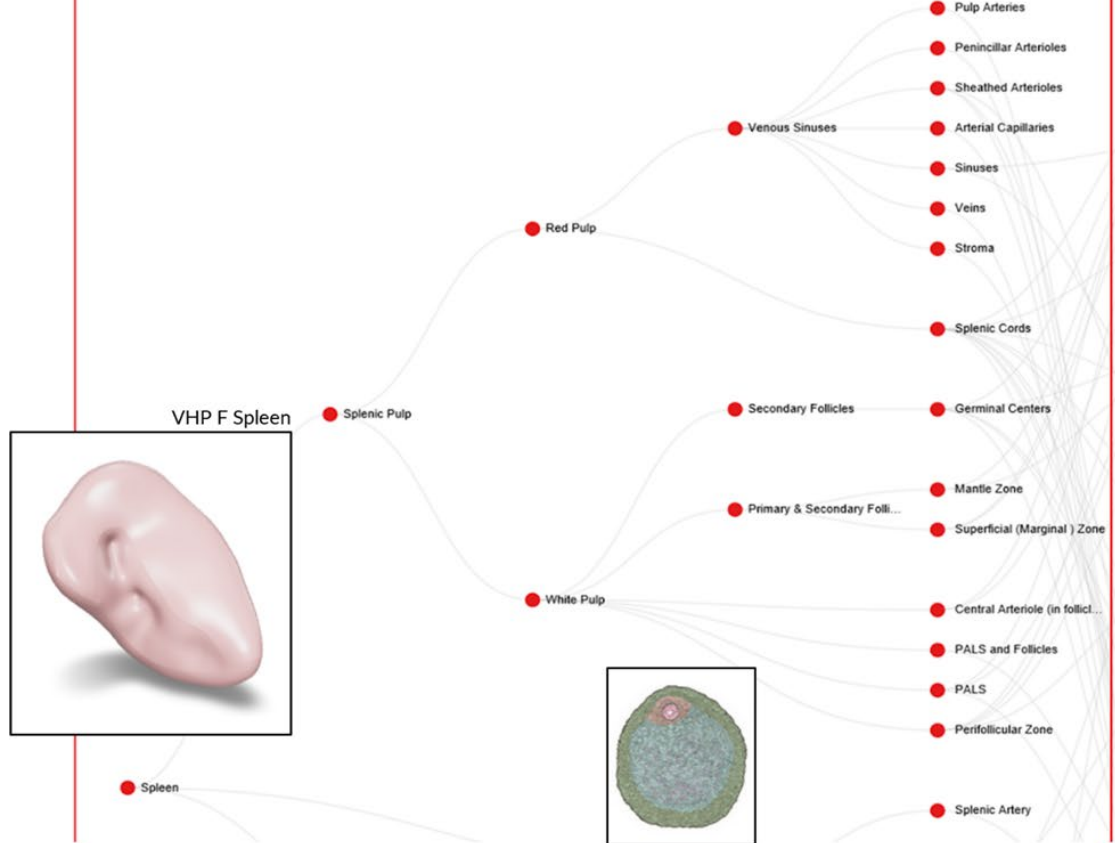
Anatomical Structures Partonomy
 kidney
 kidney capsule
 cortex of kidney
 outer cortex of kidney
 renal medulla

Cell Types Ontology
 connective tissue cell
 pericyte cell
 mesangial cell
 extraglomerular mesangial cell
 glomerular mesangial cell

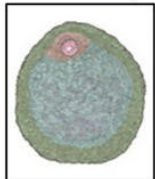
3D Reference Object Library



Partonomy Tree
part_of



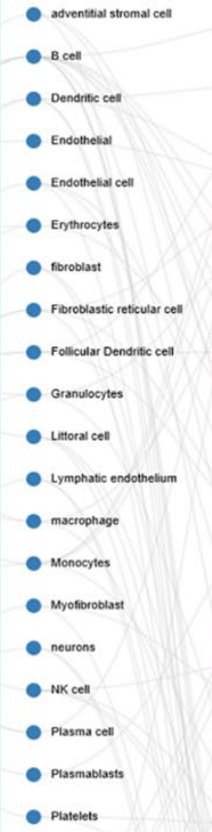
VHP F Spleen



White pulp of spleen

Typology Tree
is_a

Bimodal network describing which CT are located_in what AS

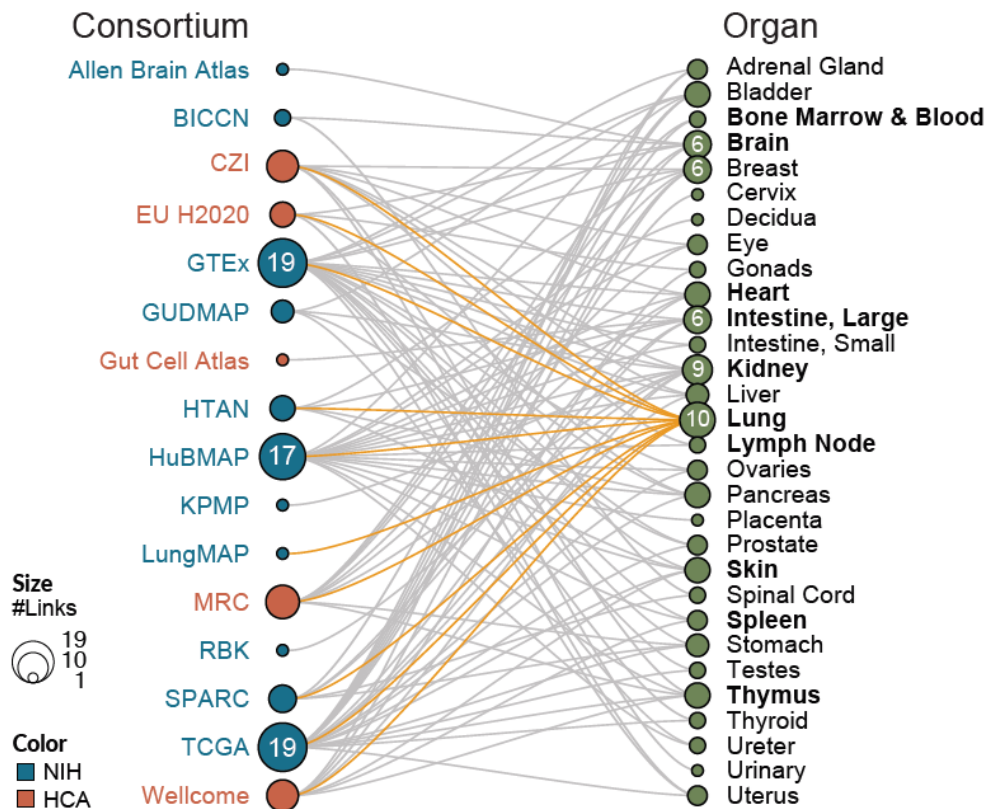


BG - Genes
BP - Proteins

Bimodal network describing which B characterize what CT



Constructing a Human Reference Atlas - Together!



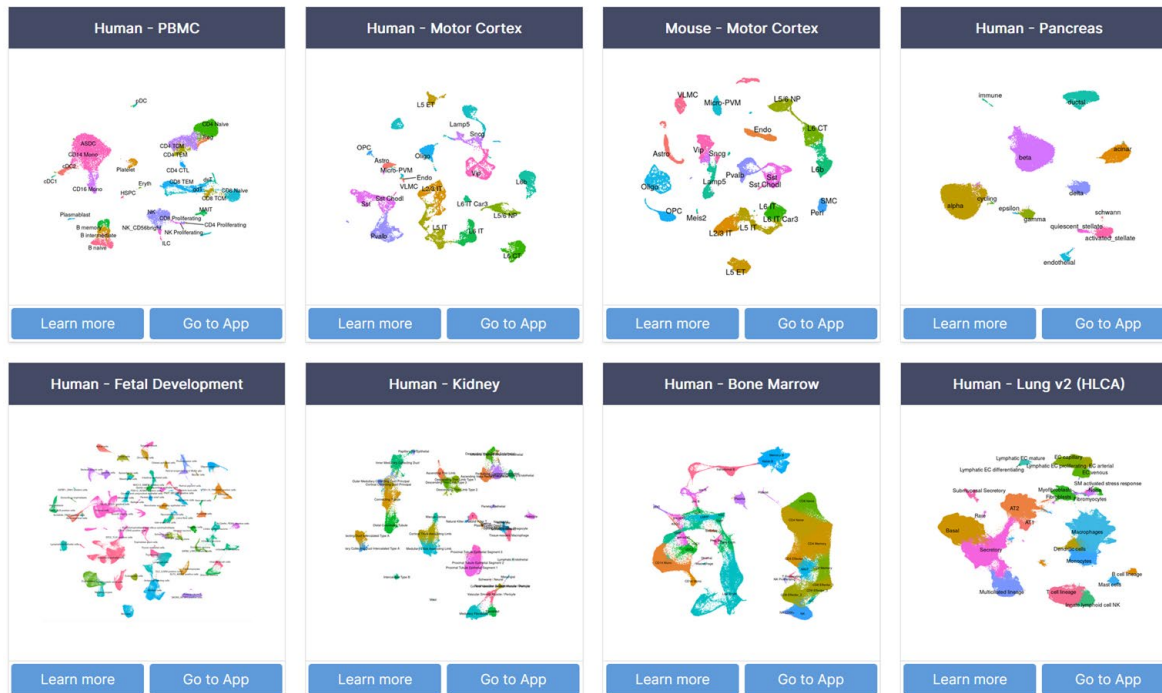
Azimuth

<https://azimuth.hubmapconsortium.org>

9 references and 1,036 cell types

> **12,000 datasets** uploaded and mapped from the community

> **187,000,000 cells** uploaded and mapped from the community



Human BioMolecular Atlas Program

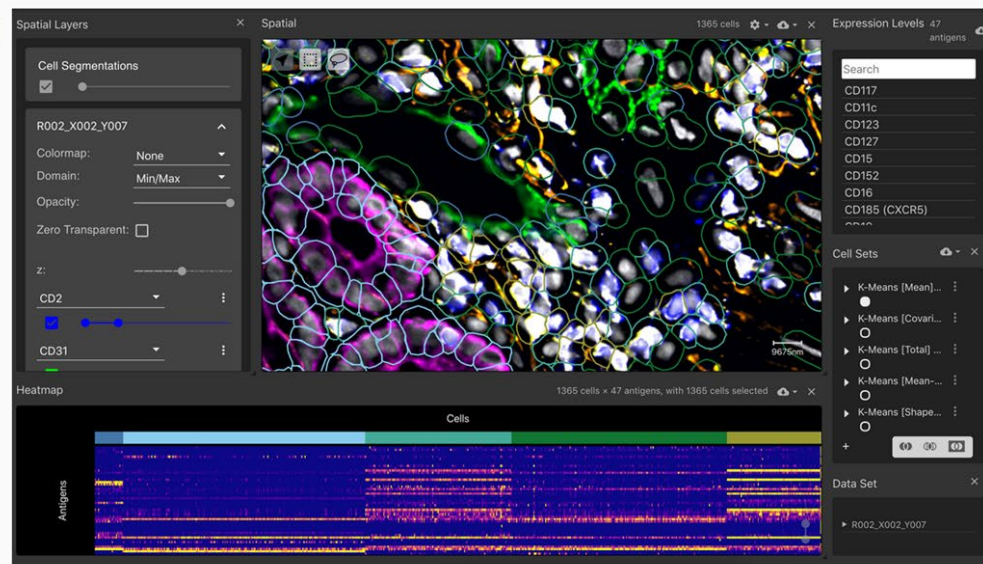
An open, global atlas of the human body at the cellular level

The HuBMAP Data Portal is the central resource for discovery, visualization, and download of single-cell tissue data generated by the consortium. A standardized data curation and processing workflow ensure that only high quality is released.

Explore spatial single-cell data with Vitessece visualizations

View multi-modal assay types with reusable interactive components such as a scatterplot, spatial+imaging plot, genome browser tracks, statistical plots and controller components.

Get Started



In October 2022



100
Donors



1105
Samples



1149
Datasets



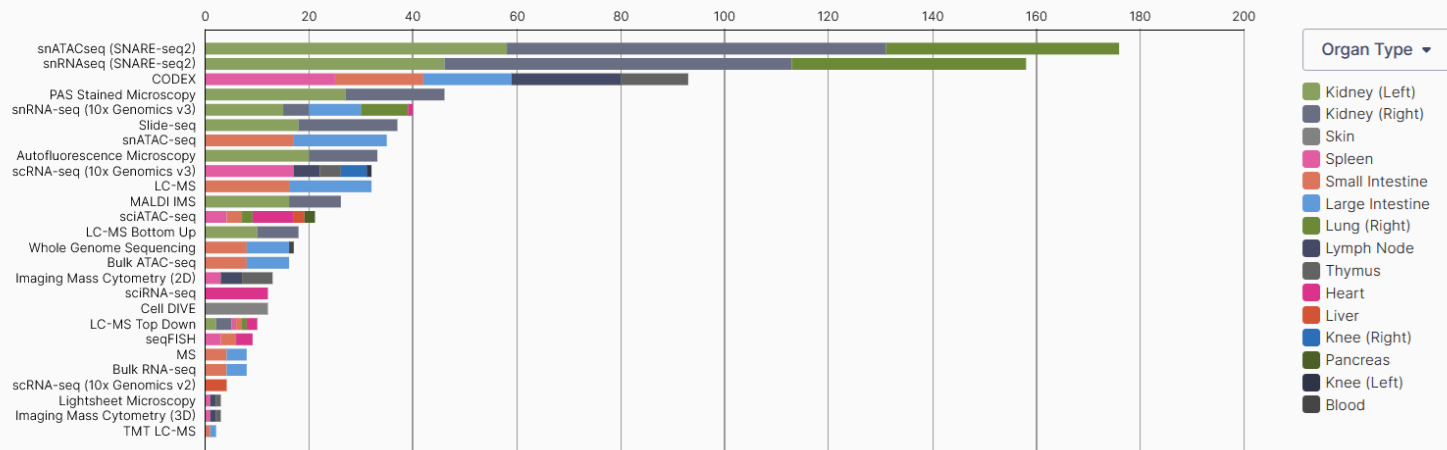
30
Organs



16
Collections

Search Portal

HuBMAP Datasets



<https://portal.hubmapconsortium.org>

30 organs / 24 assay types

HuBMAP Training

<https://expand.iu.edu/browse/sice/cns/courses/hubmap-visible-human-mooc>

- Account
- Dashboard
- Courses
- Calendar
- Inbox
- History
- Commons
- Help

No Expiration

Home

Announcements

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Discussions

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Grades

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Outcomes

Assignments

Quizzes

Collaborations

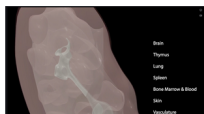
Settings

3rd HuBMAP Portal Release (June 2022)



HuBMAP Halfway Point

- HuBMAP consortia members reflect on the past four years and discuss their plans and hopes for the future.



Introduction to the HRA-CCF

- An introduction to the three ontologies at work in the Human Reference Atlas's Common Coordinate Framework: the specimen, biological structure, and spatial ontologies.



Using the EUI on the GTEx Portal

- How to cross-compare data from GTEx and HuBMAP by using the Exploration User Interface embedded in the GTEx Portal.



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. Yingye 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

HuBMAP Training

Undergraduate Summer Internships 2022

Awarded interns and placements

Fransiskus Agapa | Blood Lab - Pittsburgh Supercomputing Center

Gabrielle Lenoir | Kim Lab - University of Pennsylvania

Mohamed El Sadec | Gregory Lab - University of Pennsylvania

Marielena Grijalva | O'Neill Lab - University of Pennsylvania

Camryn Pettinger-Willey | Pasa-Tolic Lab - Pacific Northwest National Laboratory

Karli Prather | Pouch/Gee Lab - University of Pennsylvania

Li Xu | Spraggins Lab - Vanderbilt University

MJ Hopkins | Hagood Lab - University of North Carolina

Tran Nguyen | Gehlenborg Lab - Harvard Medical School

Anusha Thaniana | Pei Lab - Children's Hospital of Philadelphia

Lesley Aguilar Salceda | Satija Lab - New York Genome Center

Genna Mahabeer | Liu Lab - Northwestern University

Sangmyung Lee | Borner Lab - Indiana University, Bloomington

Undergraduate Summer Internships 2021

Awarded interns and placements

Roselkis Morla Adames | Gehlenborg Lab - Harvard Medical School

Oluwafolajinmi Olugbodi | Kim Lab - University of Pennsylvania

Kate da Silva | Kim Lab - University of Pennsylvania

Lester Casey Henson | PICSL - University of Pennsylvania

Injyil Gates | Nolan Lab - Stanford University

Ogechukwu Etuazim | O'Neill Lab - University of Pennsylvania

Stephanie Bobadilla-Regalado | Gregory Lab - University of Pennsylvania

Tatiana Gonzalez | Gregory Lab - University of Pennsylvania

JumpStart Awardees 2021

Yang Liu

Project Title: Spatial multi-omics profiling of human kidney tissue using DBIT-seq
HuMAP Lab: Yale TMC

Angela Kruse

Project Title: 3 D Multimodal Analysis of Eye and Pancreas Blocks Using Light Sheet Microscopy and Imaging Mass Spectrometry
HuMAP Lab: Vanderbilt TMC

Hang Hu

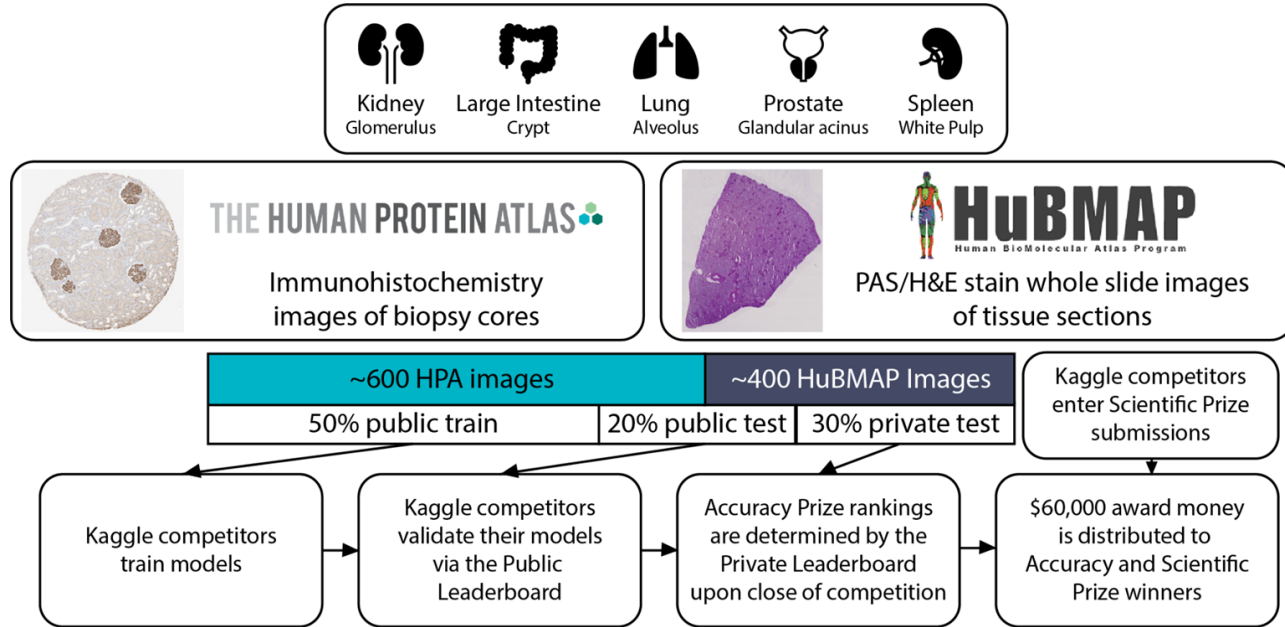
Project Title: Self-supervised Mass Spectrometry Imaging Clustering with Convolutional Neural Network and Contrastive Learning
HuMAP Lab: Purdue TTD

NIH Junior Investigator Meeting 2023

- **Goal:** The meeting will conduct several workshops with potential topics ranging from career development to equity in science to the academic vs. industrial world. For this meeting, we are planning to have several inter-consortia networking sessions with activities, expert subgroup meetings, and freeform discussions based on abstract topics from the attendees. Multiple plenary talks are being planned at the moment.
- **Dates:** March 1-3, 2023
- **Venue:** Cornell Graduate Hotel in NYC, and virtually
- **Who can attend:** For the purposes of this meeting, a ‘junior investigator’ is defined as a graduate student, postdoc, staff scientist, or early-career faculty.
- **More information:** A website with more details as well as registration will become available later this year.



HuBMAP-HPA Kaggle Competition



Accuracy Prizes:

- First Place: \$15,000
- Second Place: \$10,000
- Third Place: \$5,000

Judges Prizes:

- Scientific Prizes: 2 x \$10,000
- Diversity Prize: \$10,000

The challenge asked teams from around the globe to develop robust and generalizable machine learning algorithms that correctly segment FTUs of different shapes and sizes across five organs (large intestine, kidney, lung, prostate, and spleen), see <https://www.kaggle.com/competitions/hubmap-organ-segmentation>

Two more competitions are planned with a focus on Vasculature CCF, see <https://doi.org/10.3389/fcvm.2020.00029>

Production Phase (2022 - 2026)

3D Maps and Reference Datasets

- Common data types: RNAseq, multiplexed IF, histology datasets
- Build bridging datasets to link data types
 - Continue work on generalization of cell x gene data
- Azimuth maps for: kidney (Jain, Spraggins), lung (Pryhuber), colon (Snyder), bone marrow (Bendall, Tan), female reproductive system (Kim, Laurent), pancreas (Qian, Spraggins), heart (Tan), eye (Spraggins), skin (Ginty, Wirtz), bone (Rowe), and lymphatics (Singhal)
- Identify and generate exemplary 2D maps of FTUs
- Cross-walk experimental data to the Human Reference Atlas
- Build out Antibody Characterization / Validation Reports (AvRs) & Organ Mapping Antibody Panels (OMAPs)

Production Phase (2022 - 2026)

Demo and Collaborative Projects

- Integration with MatrisomeDB (Naba)
- Identification of Organotypic Vasculature (Gupta)
- Reverse Engineering Ovarian Organization (Laronda)
- Identification of mitochondria variants (Pei)
- Multi-tissue analysis from single donors (Pryhuber)

Outreach and Collaboration

- Continue Junior Investigators meetings, Jumpstart, Summer Internships, Kaggles...
- Organization joint workshops / meetings (e.g., HPAP)
- Plans for Enhancing Diverse Perspectives (PEDPs)
- Open Working Groups - ASCT+B, Affinity Reagents, Data Visualization [new]



Thank you!

