Breakout Session 6:

The NHBLI LungMAP Cloud Ecosystem: Connecting Diverse Digital and Lung Biology Resources

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LungMAP
Molecular Atlas of Lung Development Program

NIH National Heart, Lung, and Blood Institute

The NHBLI LungMAP Cloud Ecosystem: Connecting Diverse Digital and Biology Resources

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Grand Challenges in Lung Biology

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- Regeneration and repair
- Role of stem cells
- Developmental hierarchies
- Mechanisms of disease
- Genetics and infection

Addressing these questions challenges require:

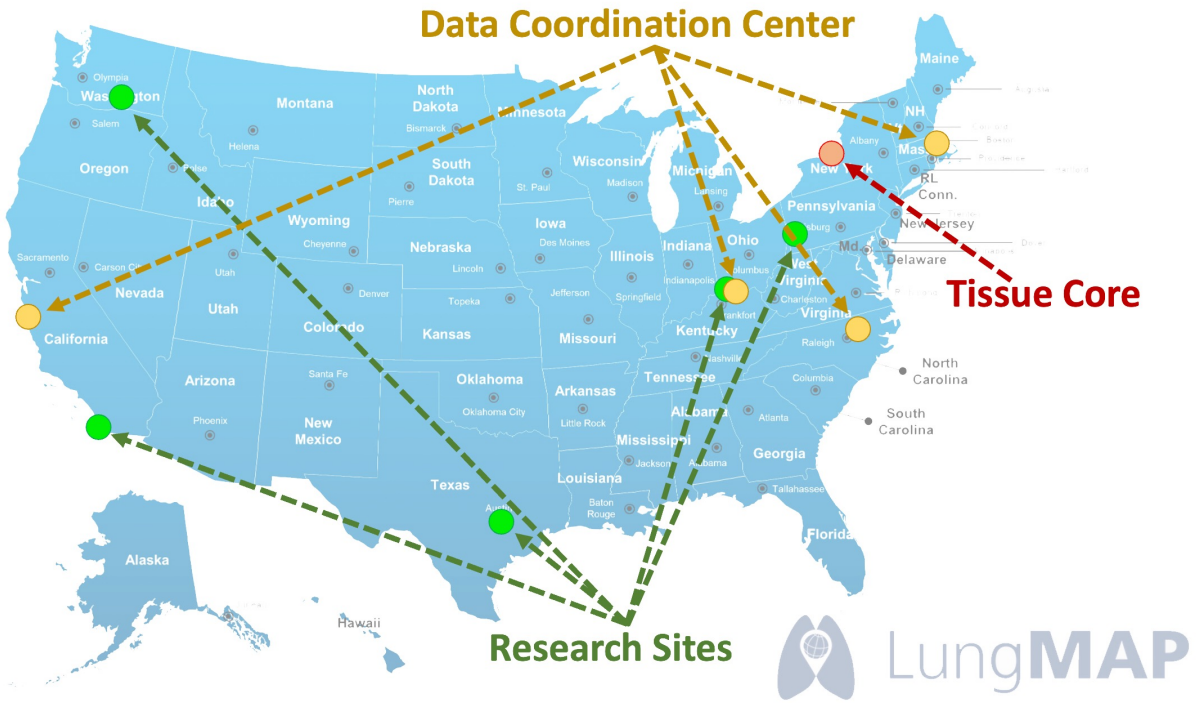
- Team science approaches with diverse experts
- New tools and techniques to construct systems models
- Integrated atlas level initiatives

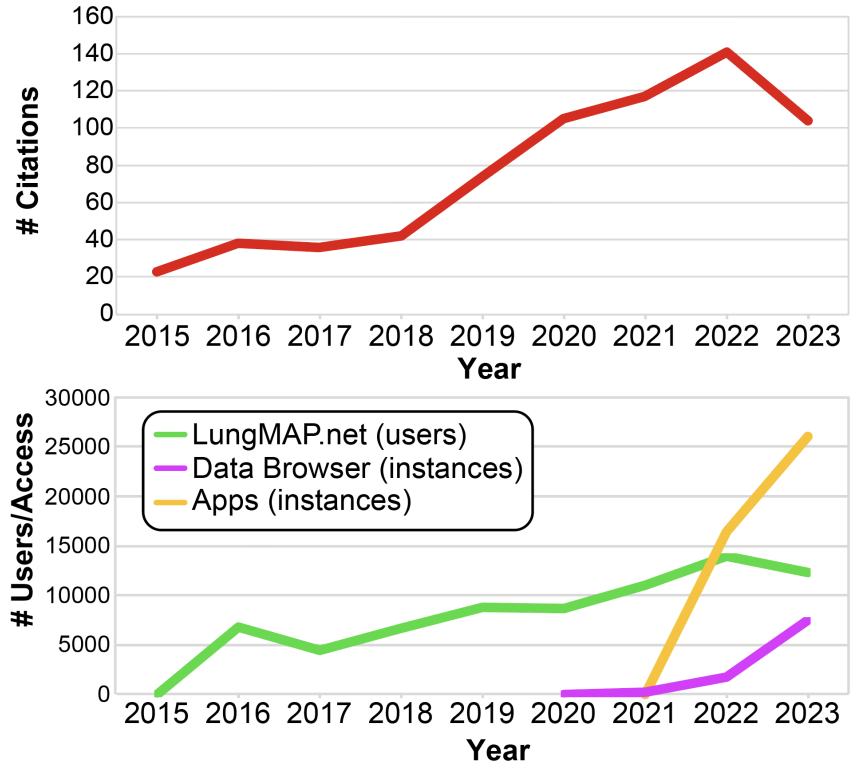
The LungMAP Consortium

LungMAP Molecular Atlas of Lung Development Program

NIH National Heart, Lung, and Blood Institute

- NHBLI consortia spanning 6 research centers over the last 10 years
- Human Tissue Core at the University of Rochester (Gloria Pryhuber)
- Data Coordination Center: CCHMC, Broad, UCSC, RTI
- *Entering Phase 3 in 2023 to create accessible atlases of lung disease*





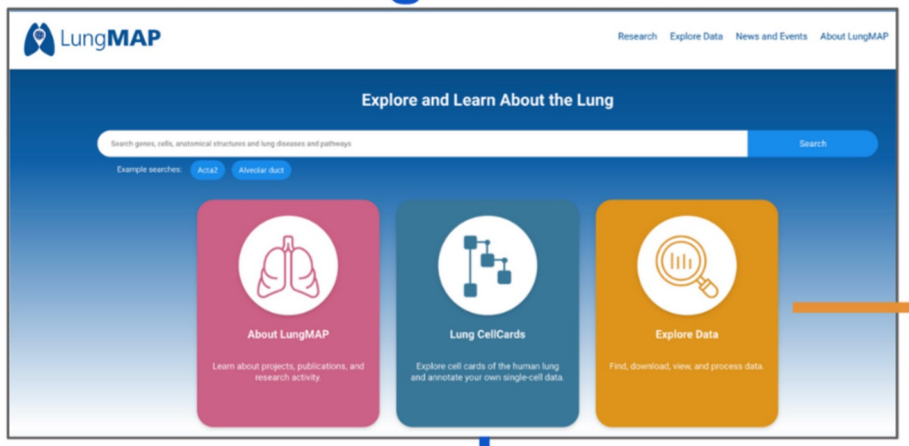
LungMAP Knowledgebase

LungMAP Molecular Atlas of Lung Development Program

NIH National Heart, Lung, and Blood Institute

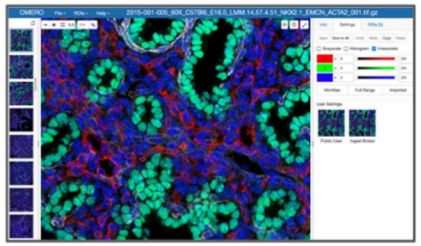
Gaddis et al. Am J Respir Cell Mol Biol. 2022

LungMAP.net

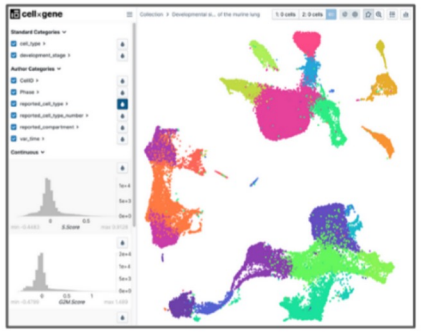


Studies

Visualize



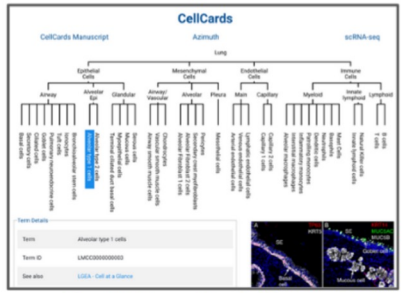
OMERO Lung Browser



CellxGene Viewer

Integrated Atlases

Explore

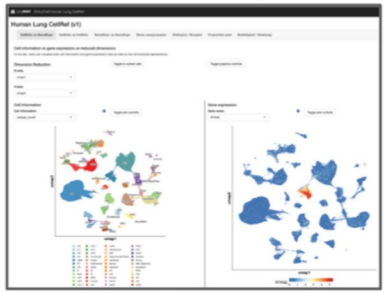


CellCards Viewer

Classify

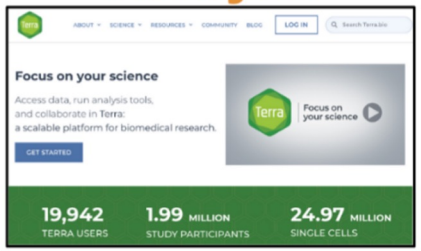
CellRef Azimuth Portals

Query



CellRef ShinyCell

Analyze



Terra Ecosystem

LungMAP.net Ecosystem

LungMAP Molecular Atlas of Lung Development Program

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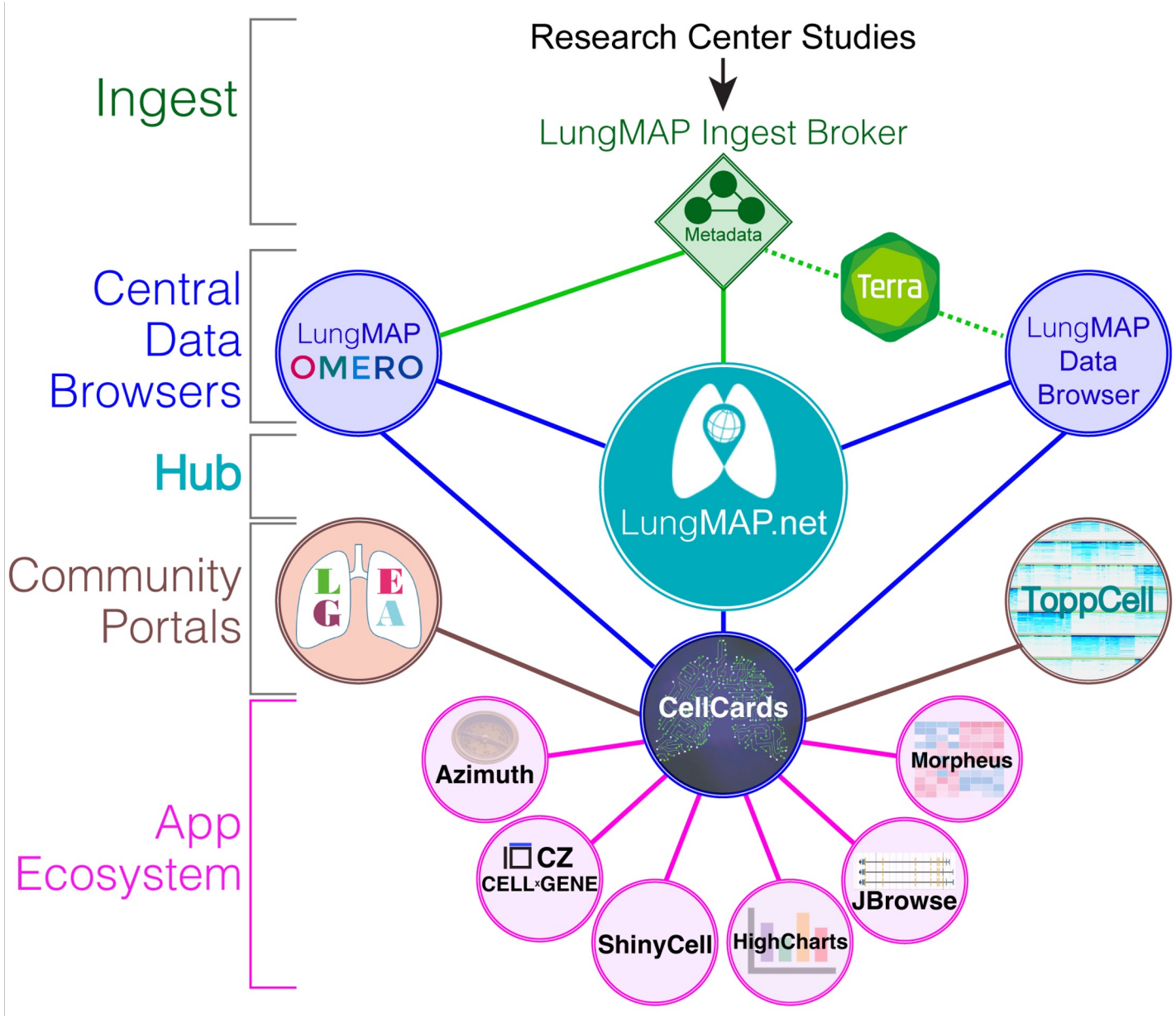

- Redesigned website
- CellCards and App focused
- Driving towards maximal interactivity (within/between)
- Pushing data and analysis to the cloud.

Gaddis et al. Am J Respir Cell Mol Biol. 2022

What are the Products of LungMAP?

LungMAP
Molecular Atlas of Lung Development Program

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- **Insights**: New cell-states, regulatory models
- **Tissues**: Biopsies, whole lung
- **Data**: Omics, imaging
- **Protocols**: Experimental, analytical
- **Tools**: Organoids, omics, informatics

LungMAP Data Flow

LungMAP Molecular Atlas of Lung Development Program

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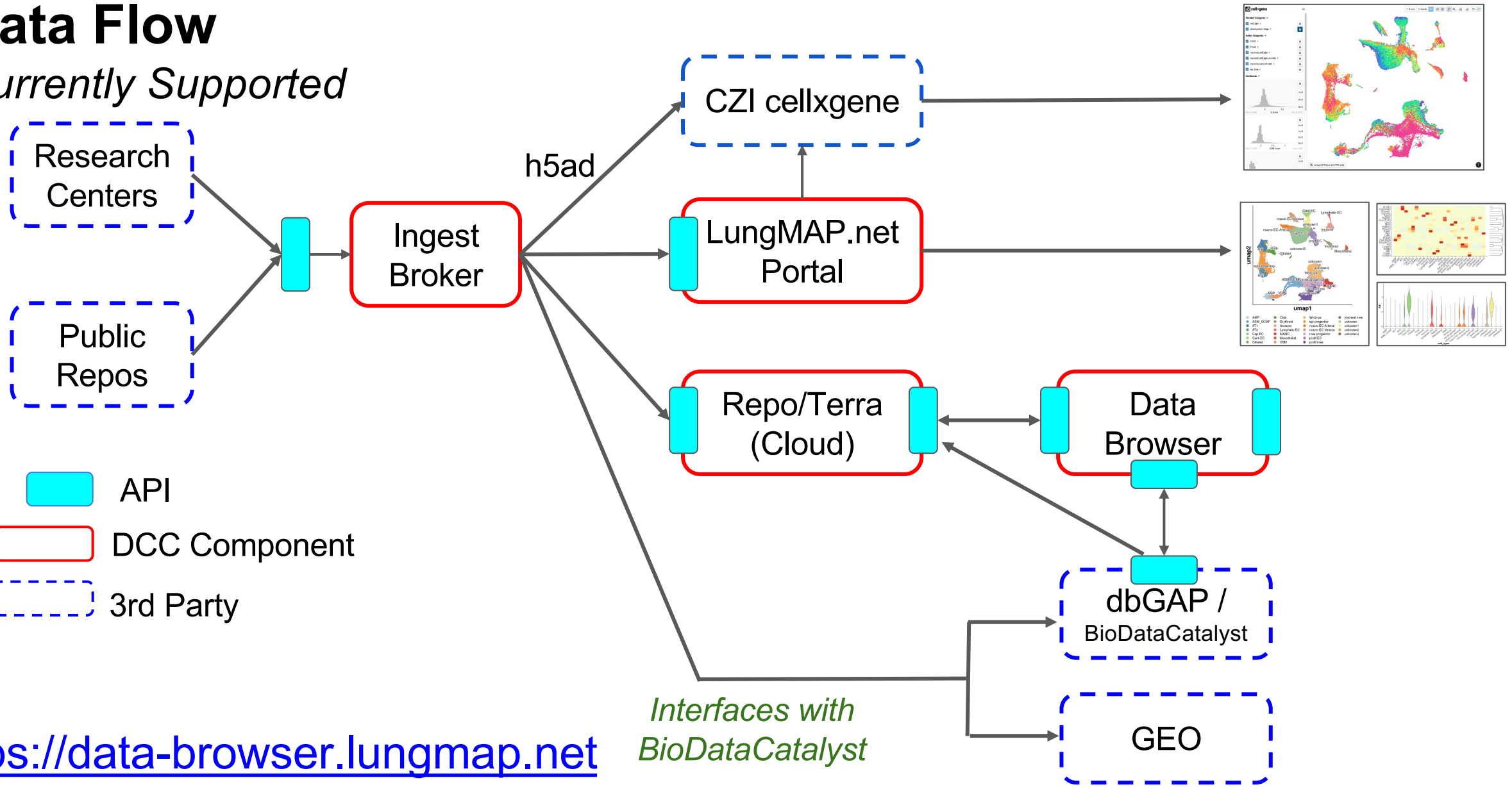
Data Flow

Currently Supported



https://data-browser.lungmap.net

LungMAP.net Website

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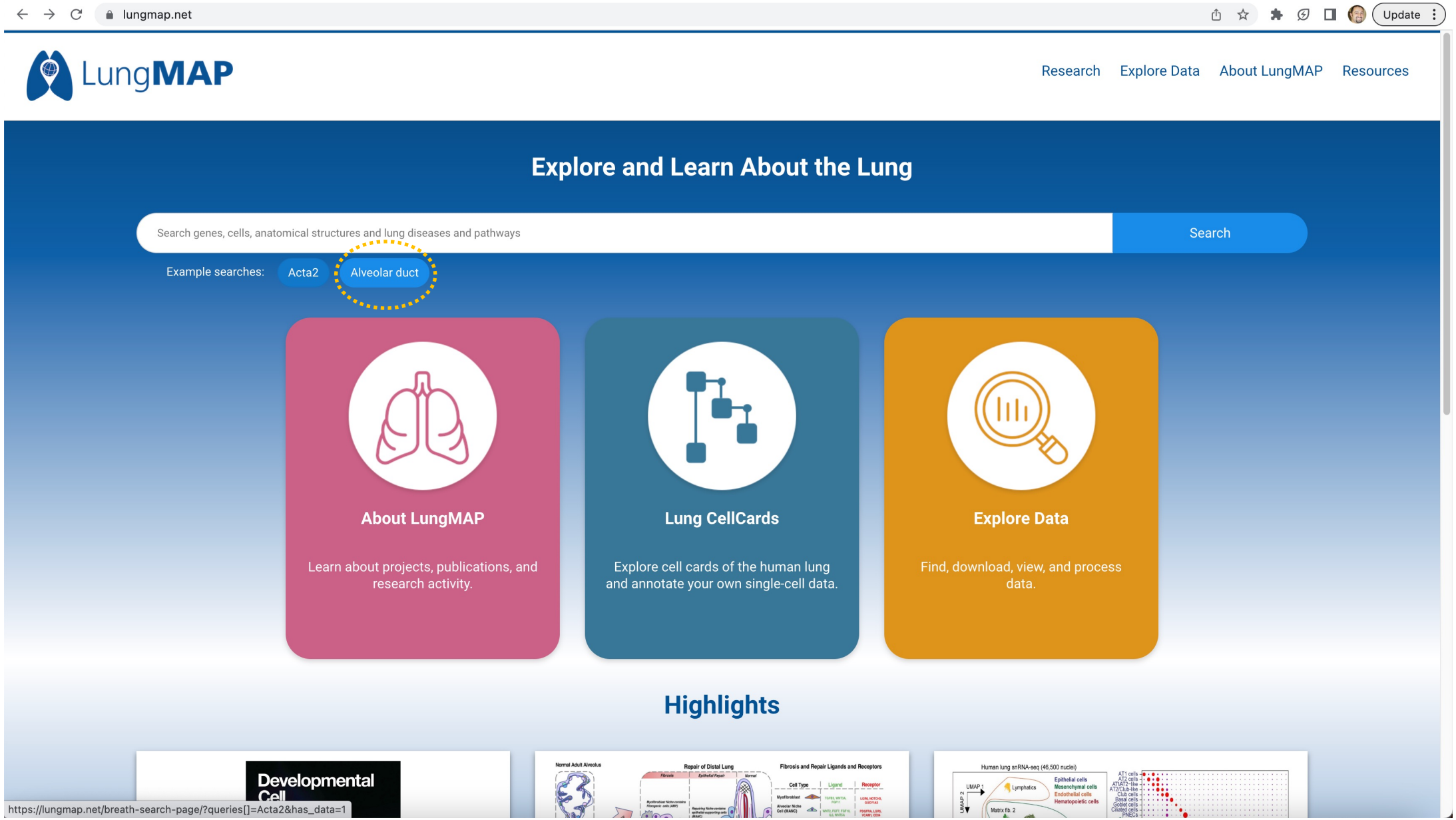

Cross-Consortia Cell-Type Curation

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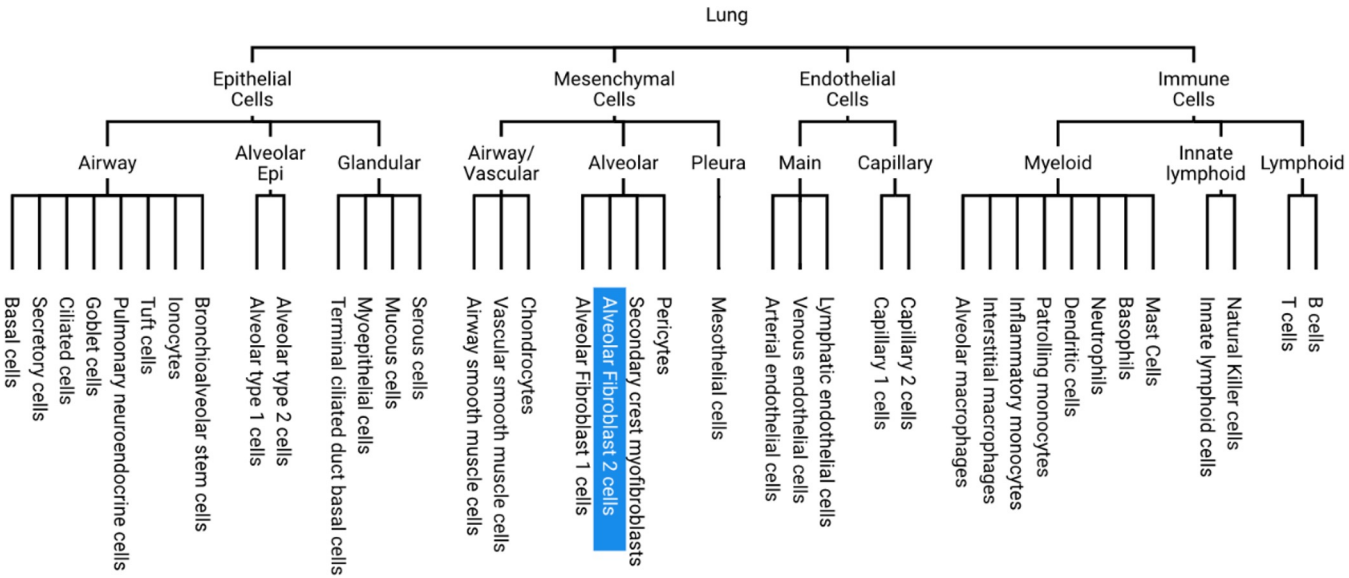
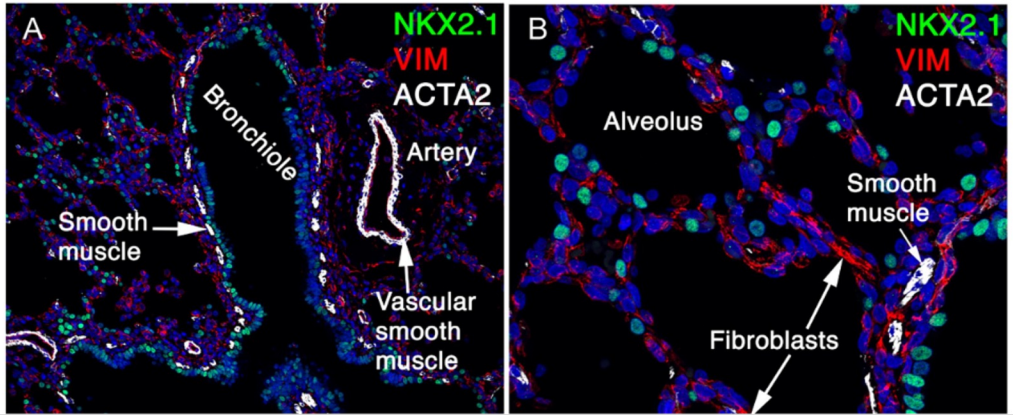
CellCards

CellCards Reference | CellRef scRNA-seq | CellRef ATAC-seq | CellRef Azimuth



Term Details

Term	Alveolar Fibroblast 2 cells
Term ID	LMCC0000000026
See also	LGEA - Cell at a Glance
Related synonyms	Type-2 associated stromal cell (TASC)(Chung, et al., 2018) | Type-2 associated stromal cell (TASC)(Chung, et al., 2018) | Adventitial fibroblast (Travaglini, et al., 2020) | Adventitial fibroblast (Travaglini, et al., 2020) | Matrix fibroblast 2 | MANC (Zepp, et al., 2017) (Park, et al., 2019) (Torday, et al., 2016) | MANC (Zepp, et al., 2017) (Park, et al., 2019) (Torday, et al., 2016) | Mesenchymal alveolar niche cell



Tissues

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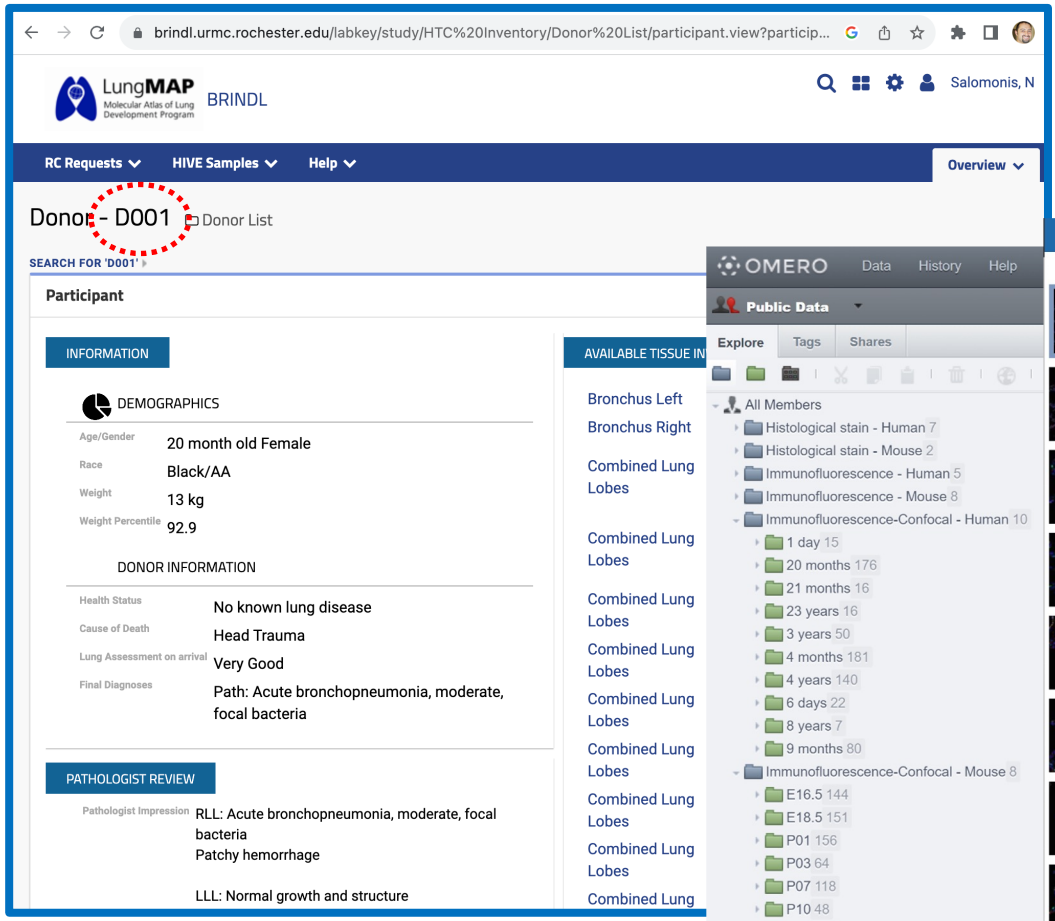
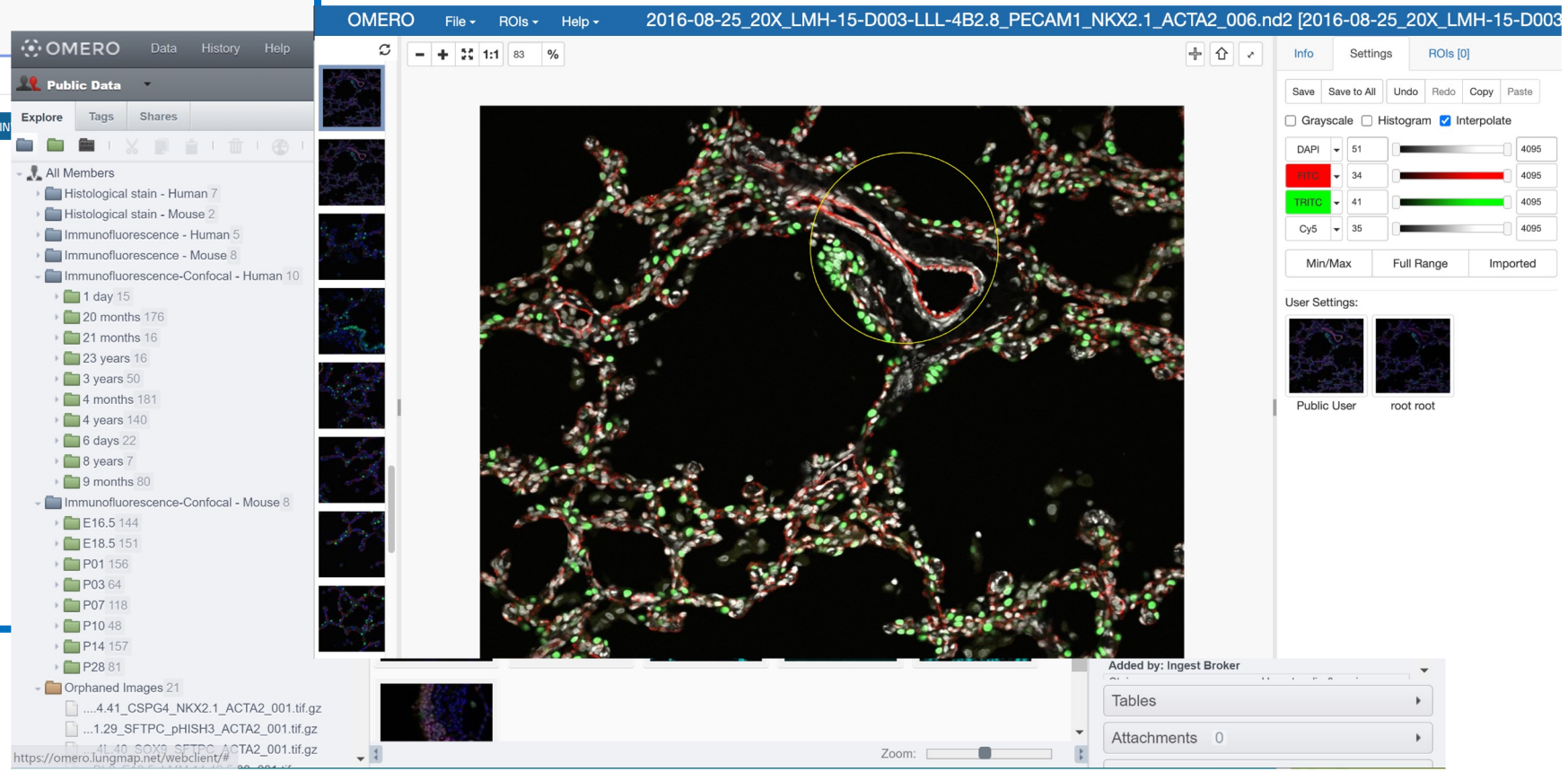
BRINDL Tissue Repository



OMERO Image Viewer



JBrowse - Epigenomic Data Browser

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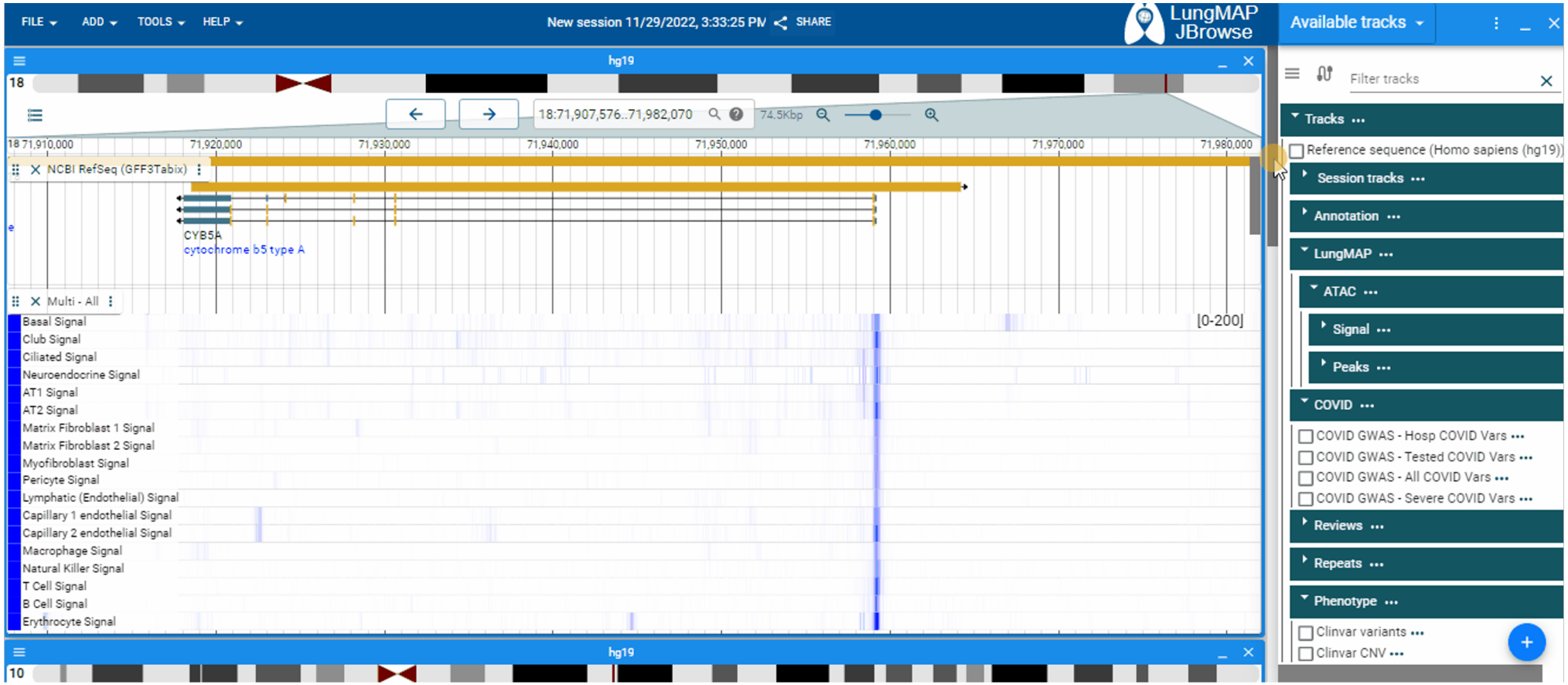
- View pre-loaded, UCSC Track Hub, or bring-your-own-track
- View and compare multiple loci (including species*)



LungMAP App Ecosystem

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Human CellCards Multi-Study CellRef 1.0 Atlas

Minzhe Guo (CCHMC) | Geremy Clair (PNNL) | Joshua N. Adkins (PNNL) | Gloria Pryhuber (HTC/URMC) | Ravi Misra (HTC/URMC) | Bruce Aronow (CCHMC) | Timothy L. Tickle (Broad) | Nathan Salomonis (CCHMC) | Xin Sun (UCSD) | Edward E. Morrisey (UPenn) | Jeffrey A. Whitsett (CCHMC) | Yan Xu (CCHMC)

How to explore data (tutorial)

Description

The "LungMAP Human Lung CellRef" atlas incorporates 48 well-defined lung cell types (CellCards) catalogued from diverse anatomic locations and stages of lung maturation. This atlas spans sc/snRNA-seq of 505,256 lung cells from 148 normal human lung samples from 104 donors from parenchyma, trachea, bonchi, bronchus SMG and small airway. This study includes 21 new lung samples. An accompanying R-shiny app (Azimuth) enables fast supervised annotation of user-provided single-cell RNA-Seq datasets (see below).

LungMAP ID: LMEX0000004396

Organism: Human

Stages: Adult | Child | Adolescent

Assay type: Single-cell RNA-seq

Technology: 10x Genomics

Reference: Guo, et al. (2022)

Exploratory Tools | Samples | Downloads

ShinyCell	CellCards	Azimuth	JBrowse	LEGA	CELLxGENE	MORPHEUS Interactive Heatmap Browser	Chart View	Omics Data Browser
(Tutorial)	(Tutorial)	(Tutorial)		(Tutorial)	(Tutorial)	(Tutorial)	(Tutorial)	(Tutorial)

Interactive Visualization & Analysis

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LungMAP LungMAP Apps

Human Lung CellRef (v1)

CellInfo vs GeneExpr | CellInfo vs CellInfo | GeneExpr vs GeneExpr | Gene coexpression | Violinplot / Boxplot

Cell information vs gene expression on reduced dimensions

In this tab, users can visualise both cell information and gene expression side-by-side on low-dimensional representions.

Dimension Reduction

Toggle to subset cells

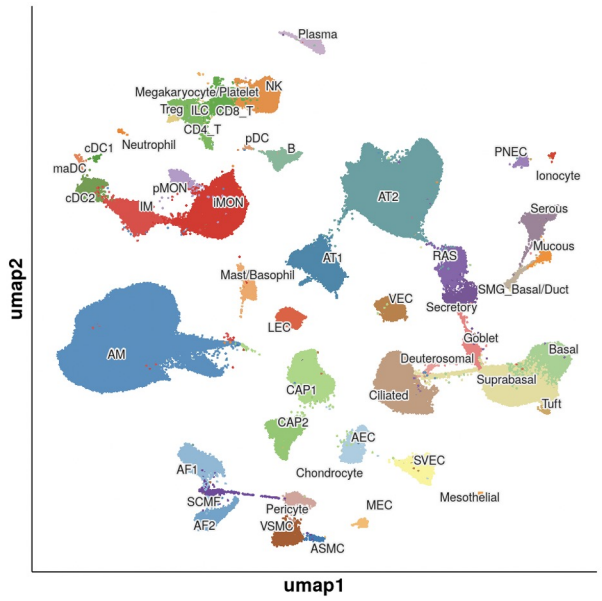
X-axis: umap1

Y-axis: umap2

Cell information

Cell information: celltype_level3

Toggle plot controls



AEC AF1 AF2 AM ASMC AT1 AT2 B Basal
CD8_T cDC1 cDC2 Chondrocyte Ciliated Deuterosomal Goblet IM
maDC Mast/Basophil MEC Megakaryocyte/Platelet Mesothelial Mucous Neutrophil NK
PNEC RAS SCMF Secretory Serous SMG_Basal/Duct Suprabasal SVEC

Gene expres

In this tab, users
The normalised e

List of gene nam
(Max 50 genes,
by , or ; or newli

DKK2, WNT2,
RTKN2, LAMP3
GPIHBP1, APL
CLEC9A, CLEC
FOXN4, MUC5
FCN1, ASCL3,
MS4A2, KRT14
FCGR3B, GNL
MZB1, TNFRSF
ITGBL1, CYP2

Group by: celltype_level3

Plot type: Bubbleplot

Scale gene ex

Cluster rows

Cluster colum

Toggle to subs

Toggle graphics

Colour scheme:
White-Red
Blue-Yellow-R
Yellow-Green-

Plot size: Small Me

Font size:

LungMAP LungMAP Apps

Azimuth

File Upload ?

Browse... No file selected

Load Adult Human Demo

Load e15.5 Mouse Demo

8567 cells uploaded
8567 cells preprocessed
8567 cells mapped
in 38 seconds

Welcome

Preprocessing

Cell Plots

Feature Plots

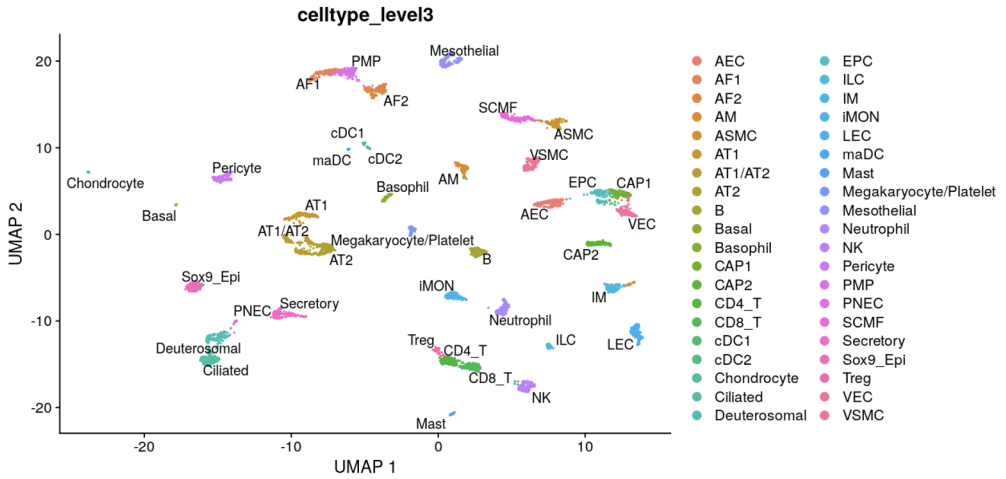
Download Results

debug ID: 1ef08560e2f4
Azimuth version: 0.4.3
Seurat version: 4.0.3
Reference version: 0.0.0

Reference

Show labels Show legend

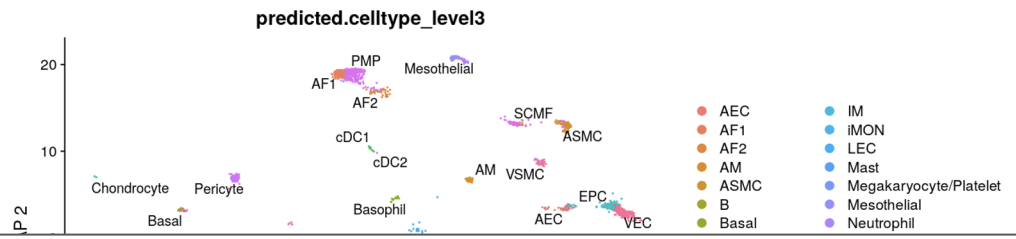
Metadata to color by: celltype_level3



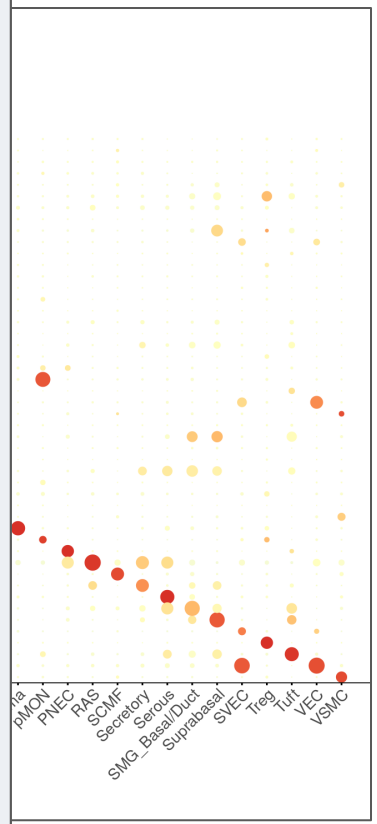
AEC AF1 AF2 AM ASMC AT1 AT1/AT2 AT2 B Basal Basophil CAP1 CAP2 CD4_T CD8_T cDC1 cDC2 Chondrocyte Ciliated Deuterosomal
EPC ILC IM iMON LEC maDC Mast Megakaryocyte/Platelet Mesothelial Neutrophil NK Pericyte PMP PNEC SCMF Secretory Sox9_Epi Treg VEC VSMC

Query

Metadata to color by: predicted.celltype_level3



AEC AF1 AF2 AM ASMC B Basal IM iMON LEC Mast Megakaryocyte/Platelet Mesothelial Neutrophil



Protocols

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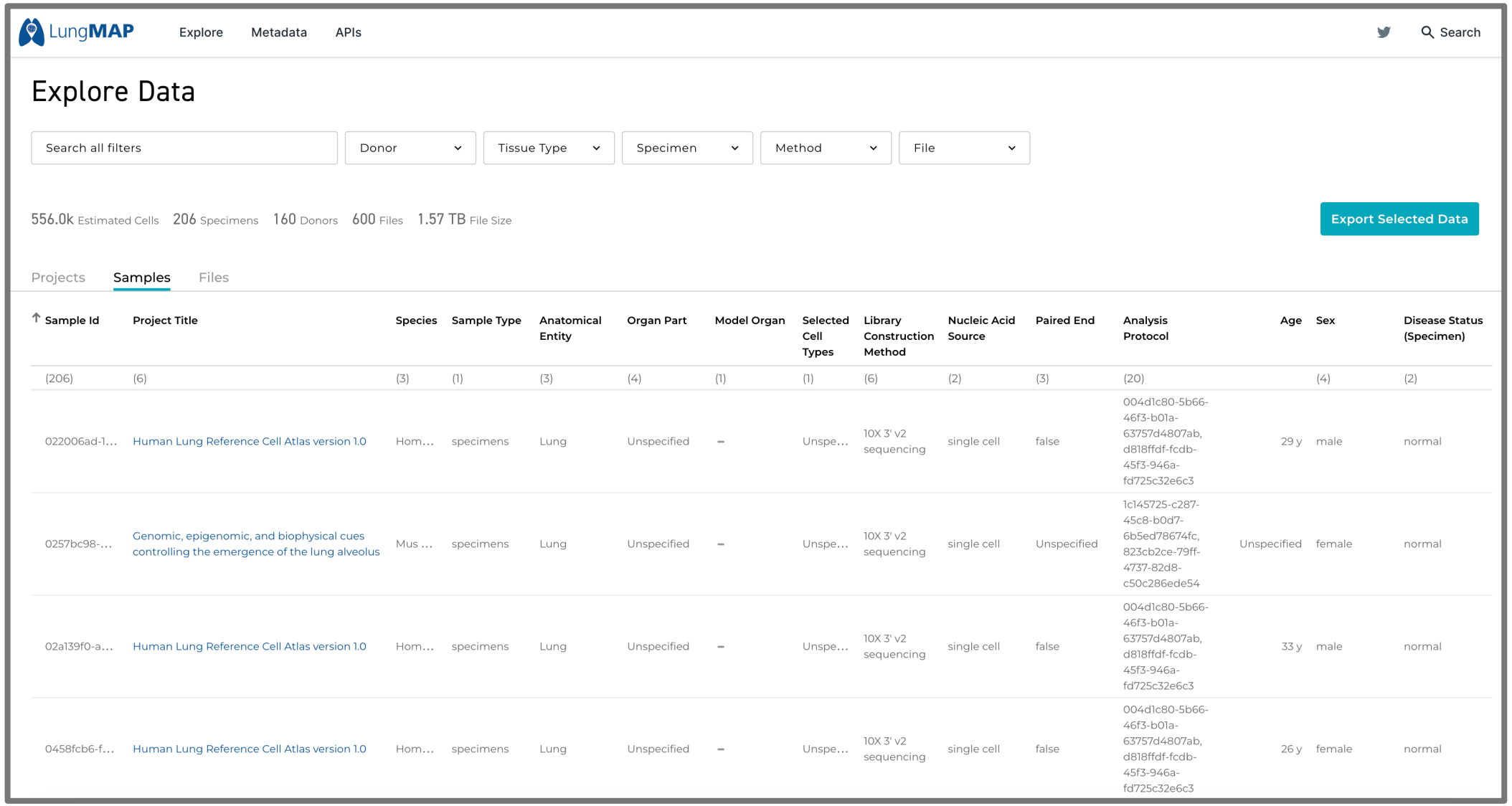
#3 – LungMAP-HCA Data/Metadata Explorer



Sample Id	Project Title	Species	Sample Type	Anatomical Entity	Organ Part	Model Organ	Selected Cell Types	Library Construction Method	Nucleic Acid Source	Paired End	Analysis Protocol	Age	Sex	Disease Status (Specimen)
(206)	(6)	(3)	(1)	(3)	(4)	(1)	(1)	(6)	(2)	(3)	(20)		(4)	(2)
022006ad-1…	Human Lung Reference Cell Atlas version 1.0	Hom…	specimens	Lung	Unspecified	–	Unspe…	10X 3' v2 sequencing	single cell	false	004d1c80-5b66-46f3-b01a-63757d4807ab, d818ffdf-fcdb-45f3-946a-fd725c32e6c3	29 y	male	normal
0257bc98-…	Genomic, epigenomic, and biophysical cues controlling the emergence of the lung alveolus	Mus …	specimens	Lung	Unspecified	–	Unspe…	10X 3' v2 sequencing	single cell	Unspecified	1c145725-c287-45c8-b0d7-6b5ed78674fc, 823cb2ce-79ff-4737-82d8-c50c286ede54	Unspecified	female	normal
02a139f0-a…	Human Lung Reference Cell Atlas version 1.0	Hom…	specimens	Lung	Unspecified	–	Unspe…	10X 3' v2 sequencing	single cell	false	004d1c80-5b66-46f3-b01a-63757d4807ab, d818ffdf-fcdb-45f3-946a-fd725c32e6c3	33 y	male	normal
0458fcb6-f…	Human Lung Reference Cell Atlas version 1.0	Hom…	specimens	Lung	Unspecified	–	Unspe…	10X 3' v2 sequencing	single cell	false	004d1c80-5b66-46f3-b01a-63757d4807ab, d818ffdf-fcdb-45f3-946a-fd725c32e6c3	26 y	female	normal

Terra-powered Cloud Resources

LungMAP Molecular Atlas of Lung Development Program

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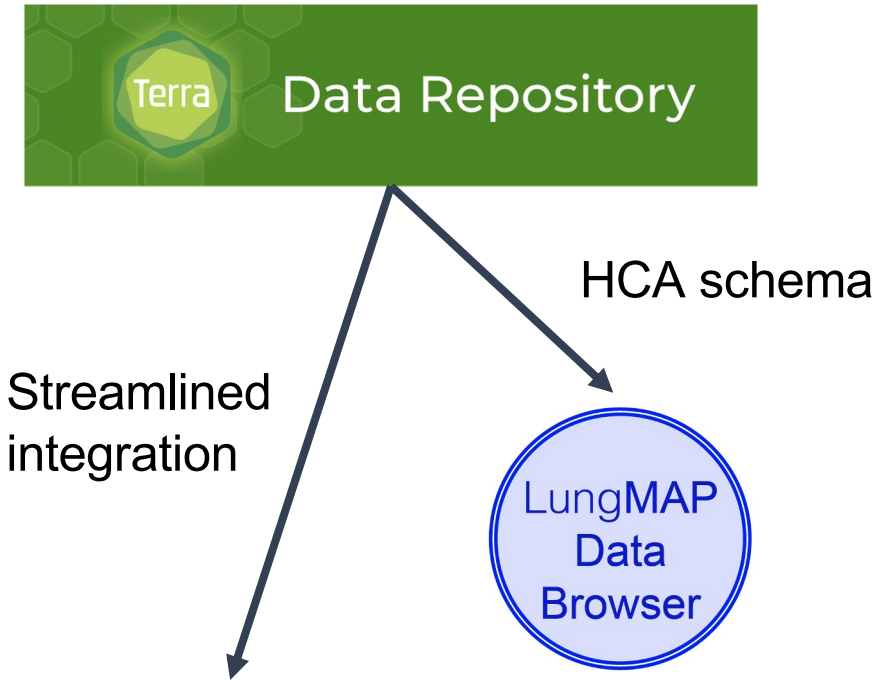
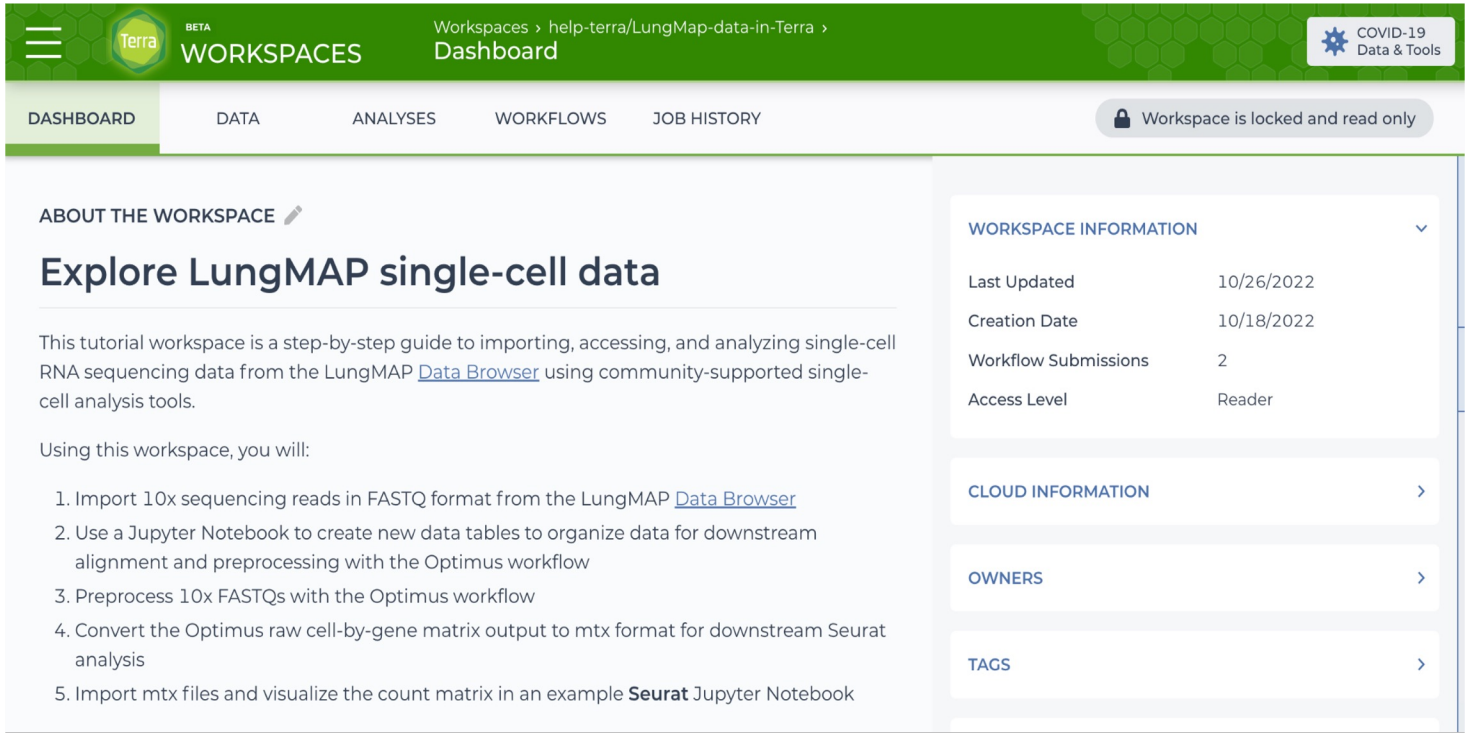
Open-access data repository facilitating integration with NHLBI ecosystem



NIH National Heart, Lung, and Blood Institute | BioData CATALYST

Cloud workspace for scalable analysis



Tutorials: https://lungmap.net/resources-2/tutorials/

- ➔ Tutorial 5: Cloud-based omics data analysis with Terra
- ➔ Video 2: Exploring and Analyzing LungMAP Data in Terra

Terra

Next steps for LungMAP

LungMAP Molecular Atlas of Lung Development Program

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- **Exponential Growth**: Dozens of new atlases & interfaces
- **Creating atlases in the cloud**: Public + consortia + user
- **Leveraging AI**: User facing language models and disease gene regulatory network models.
- **Cost management**: Balancing growth, community needs and cloud versus on prem compute.

Thank you!

LungMAP Molecular Atlas of Lung Development Program

NIH National Heart, Lung, and Blood Institute

DCC Leadership

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Eric Bardes

Scott Tabar

Joshua Fortriede

Kevin Burns

Liam Dolan

Benjamin Crooks

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with assistance from CZI and the NIH Strides & dbGAP team