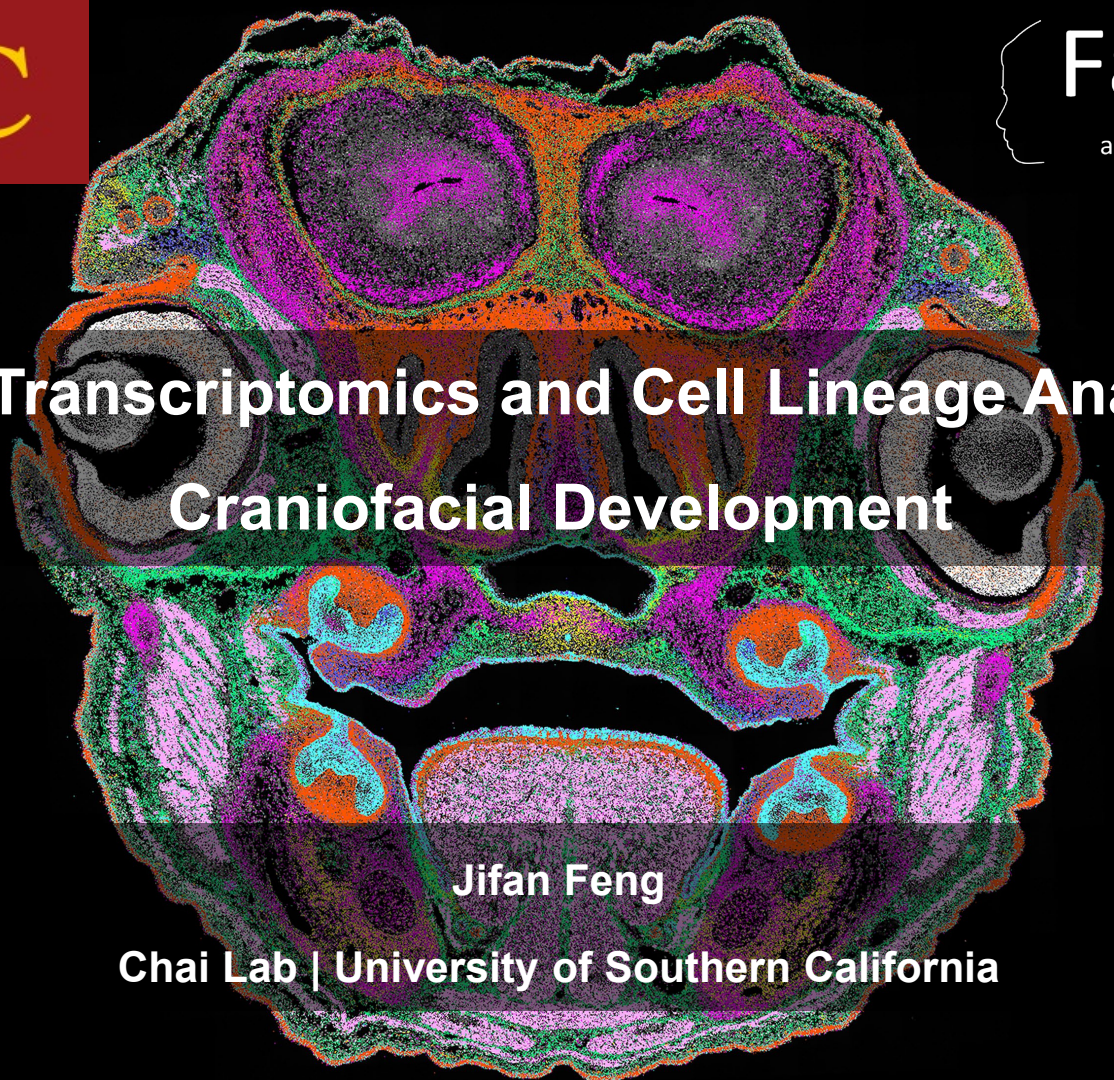
USC

FaceBase
A Resource for Dental and Craniofacial Researchers



Spatial Transcriptomics and Cell Lineage Analysis in Craniofacial Development

Jifan Feng

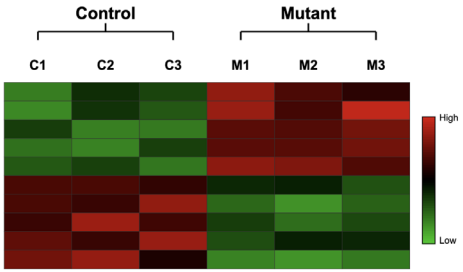
Chai Lab | University of Southern California

Disclosure

We have no conflicts of interest to disclose.

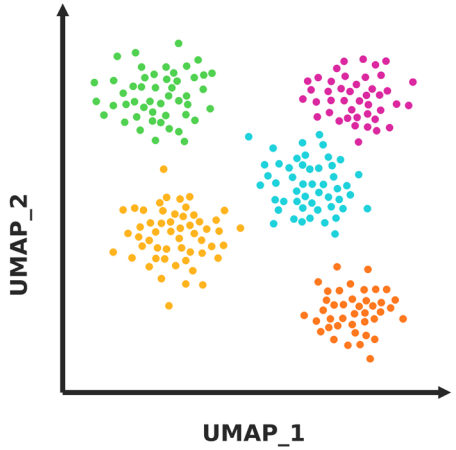
From bulk to spatial: the evolution of transcriptomics

Bulk RNA-seq



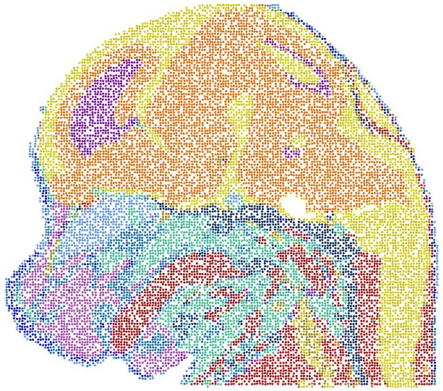
Tissue-level gene expression averaging

scRNA-seq



Single-cell resolution, no spatial context

Spatial Transcriptomics



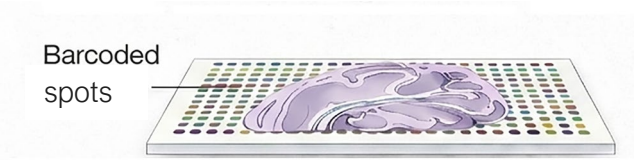
Gene expression mapped *in situ*

Sequencing-based and imaging-based platforms for spatial genomics

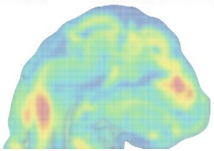
Sequencing-Based

Whole transcriptome | 0.5–55 µm resolution

Visium 55 µm | **Visium HD** 2 µm | **Stereo-seq** 0.5µm | **Slide-seq** 10 µm



Sequencing



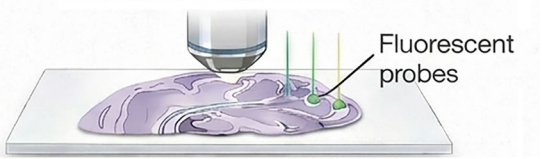
Computational
reconstruction

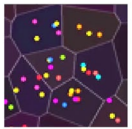
Position from barcode

Imaging-Based

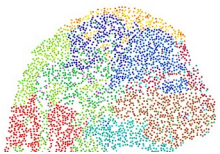
Targeted gene panel | Subcellular resolution

seqFISH | **Xenium** | **MERFISH** | **CosMx** — *all subcellular resolution*





Imaging



Signal
decoding

Single-
molecule
map

Position from microscope

Spatial genomics in craniofacial development

MOUSE

Multimodal spatiotemporal transcriptomic resolution of embryonic **palate** osteogenesis

Nature Communications
Piña et al. 2023
Visium

High-resolution spatial transcriptomics and cell lineage analysis reveal spatiotemporal cell fate determination during **craniofacial** development

Nature Communications
Feng et al. 2025
seqFISH

Spatial transcriptomics reveals a role for sensory nerves in preserving **cranial suture** patency through modulation of BMP/TGF-β signaling

PNAS
Tower et al. 2021
Visium

Single cell spatial transcriptomics links Wnt signaling disruption to extracellular matrix development in a cleft **palate** model

Scientific Reports
Piña et al. 2025
Visium HD + Xenium

HUMAN

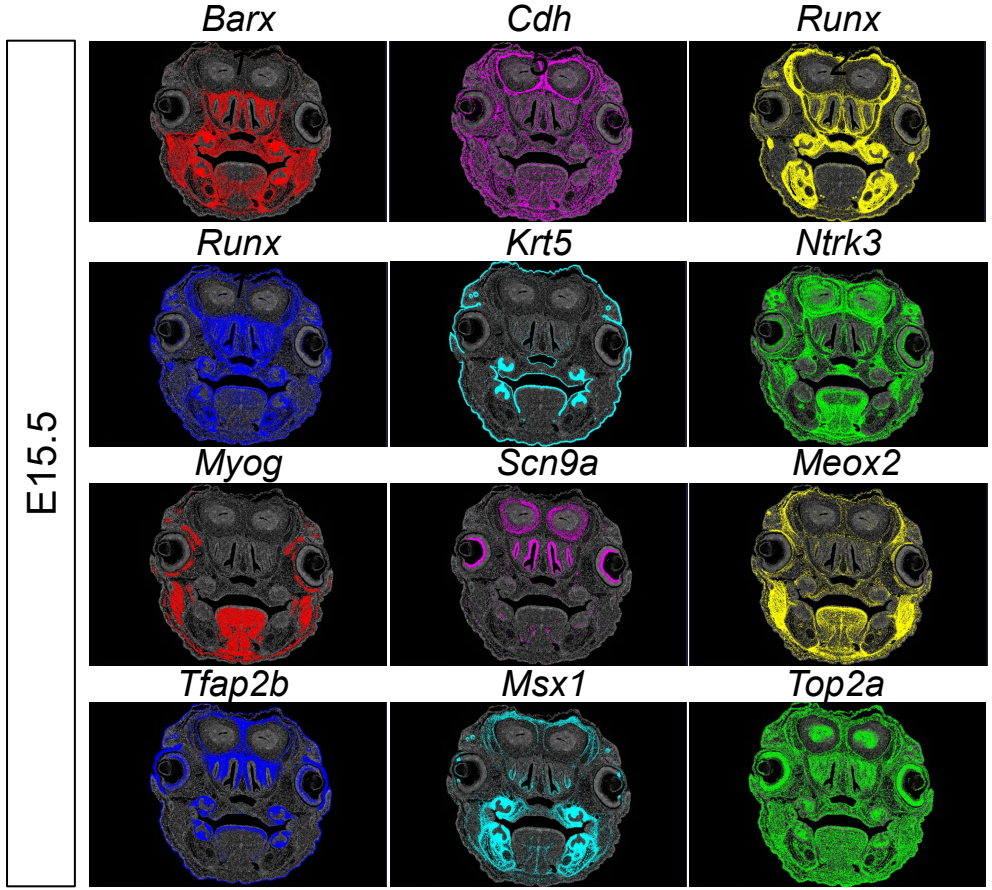
Integrated multi-omics profiling characterizes the crucial role of human dental epithelium during **tooth** development

Cell Reports
Zhang et al. 2025
Visium

An atlas of early human mandibular endochondral and osteogenic paracrine signaling regions of **Meckel's cartilage**

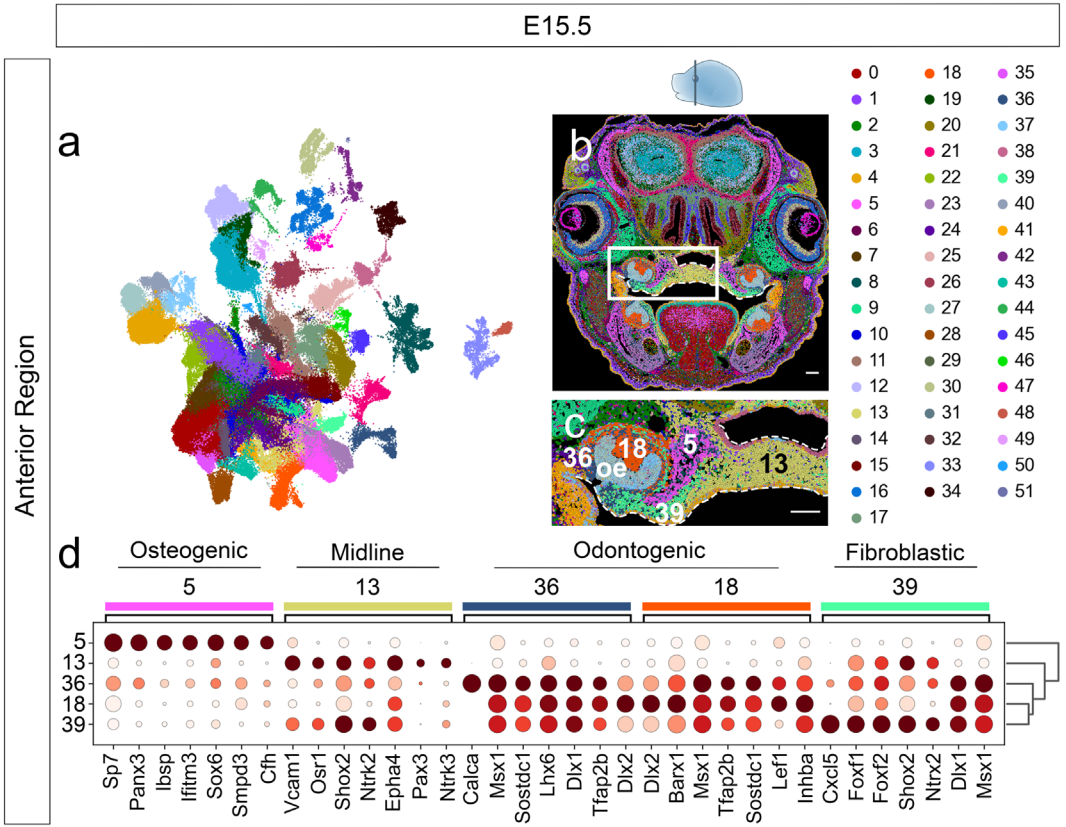
PNAS
Shen et al. 2025
Stereo-seq

Spatial genomics data as a spatially resolved gene expression atlas of the craniofacial complex



Feng et al., Nat Commun 2025

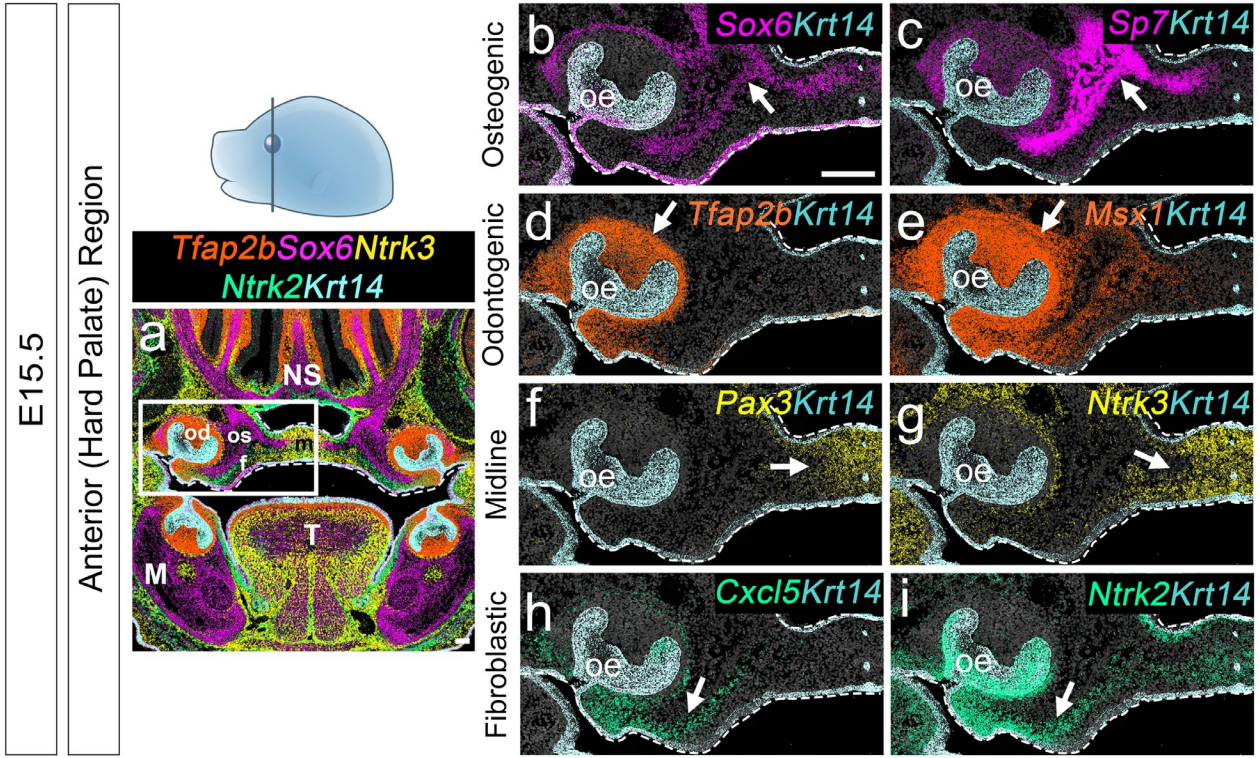
Spatial mapping of mesenchymal populations in the anterior region of the E15.5 mouse head



Abbreviations: odontogenic epithelium (oe)

Feng et al., Nat Commun 2025

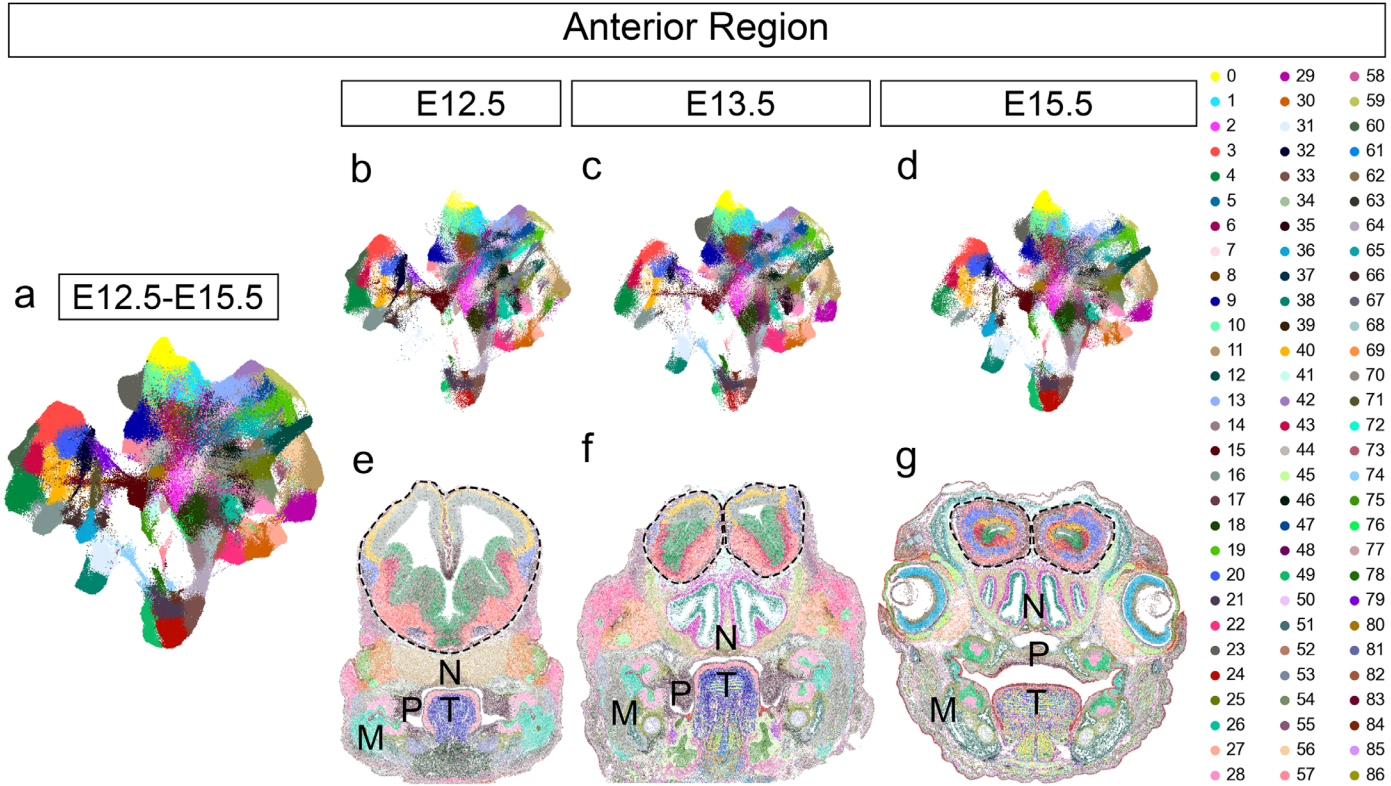
Spatially variable gene detection across cell types in craniofacial tissues



Abbreviations: fibroblasts (f), mandible (M), midline (m), nasal septum (NS), odontogenic region (od), odontogenic epithelium (oe), osteogenic region (os), tongue (T)

Feng et al., Nat Commun 2025

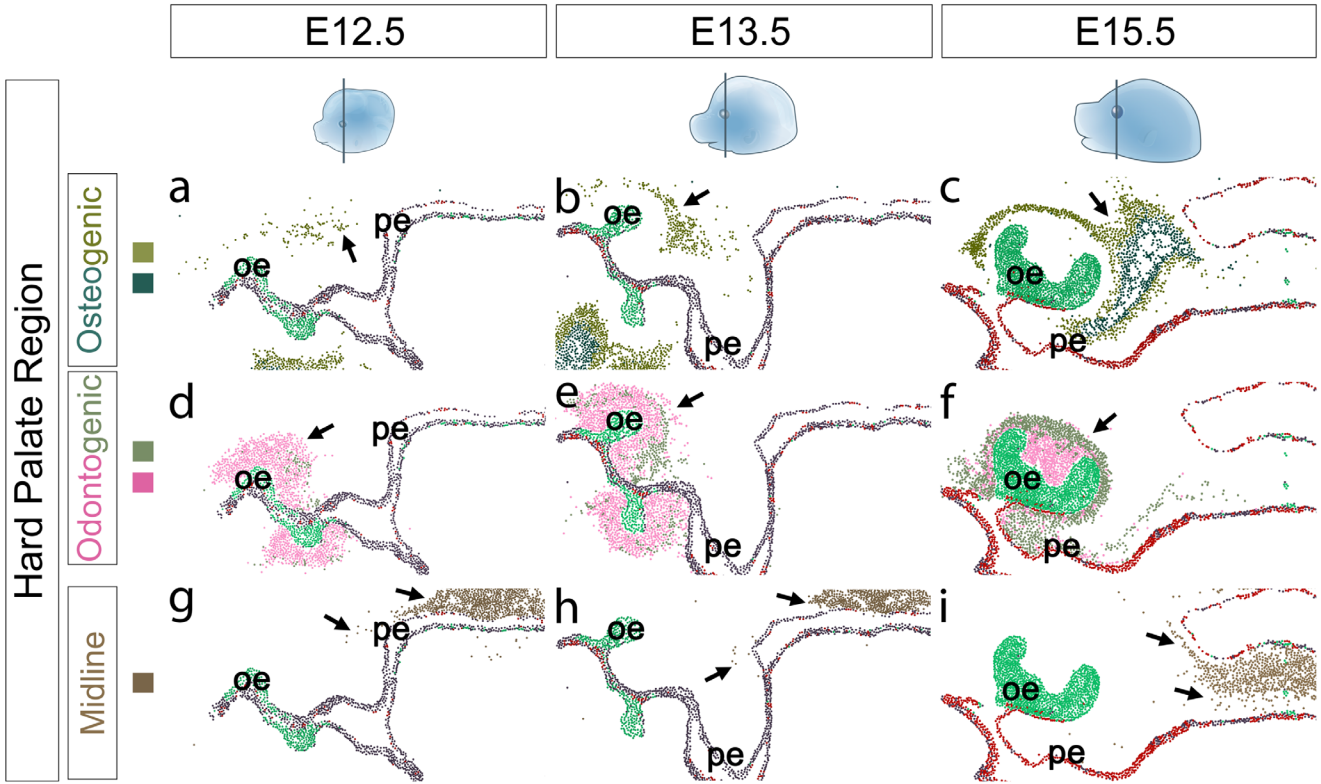
Dynamic spatial and temporal mapping of anterior craniofacial cell populations



Abbreviations: nasal region (N), mandible (M), palate (P), tongue (T)

Feng et al., Nat Commun 2025

Dynamic spatial and temporal mapping of mesenchymal populations associated with the maxillary region



Abbreviations: odontogenic epithelium (oe), palatal epithelium (pe)

Feng et al., Nat Commun 2025

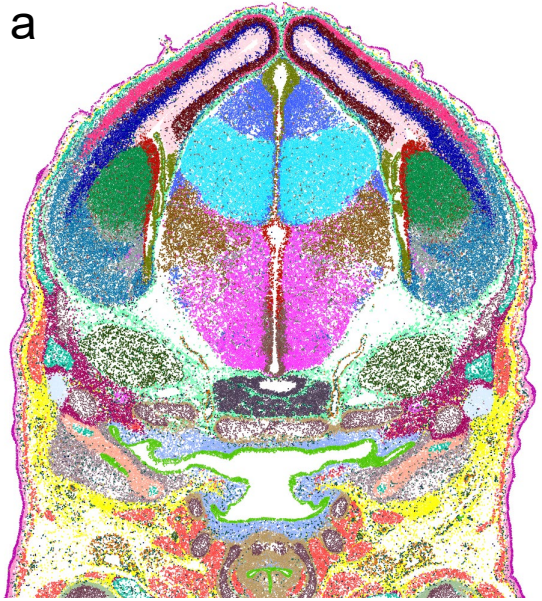
Spatial analysis identified location-specific cellular differences in control and mutant mice

Control

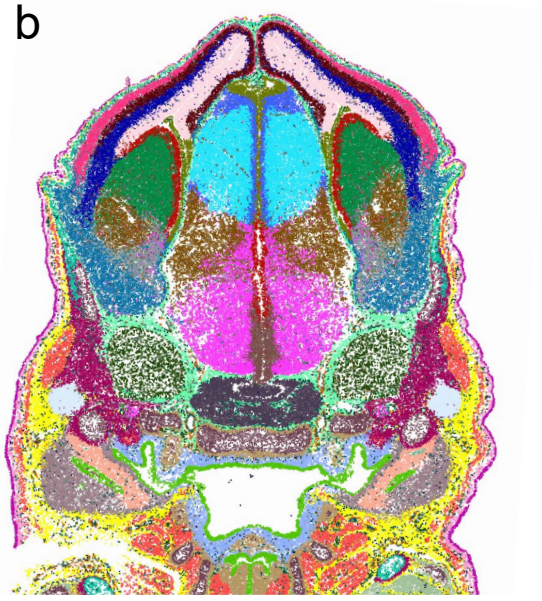
AvCreERT2;Gdf11$^{fl/fl}$

E14.0

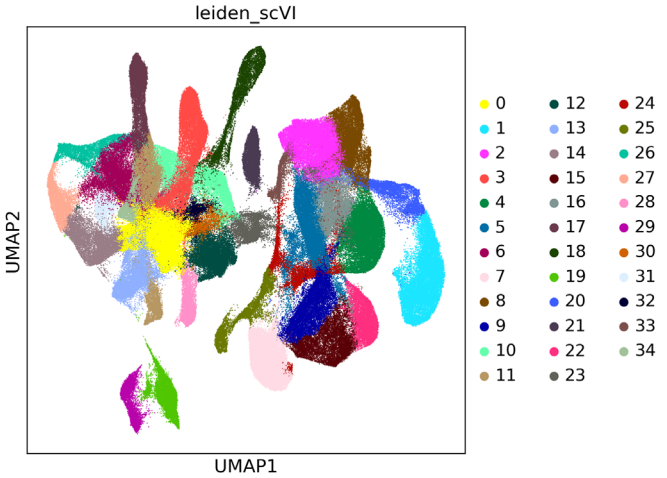
a



b

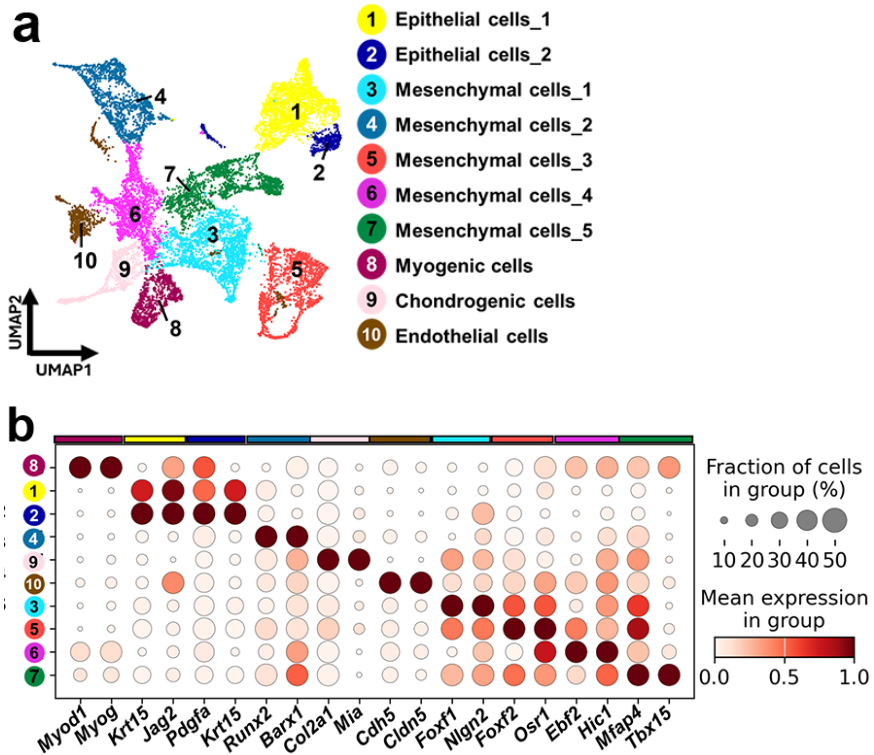


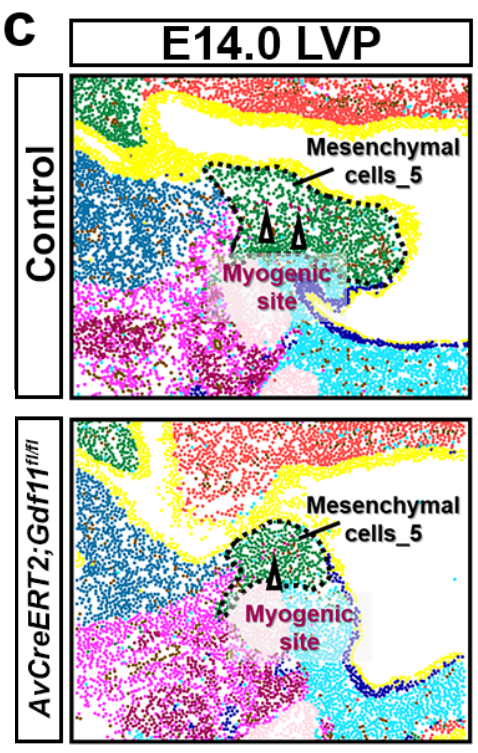
c

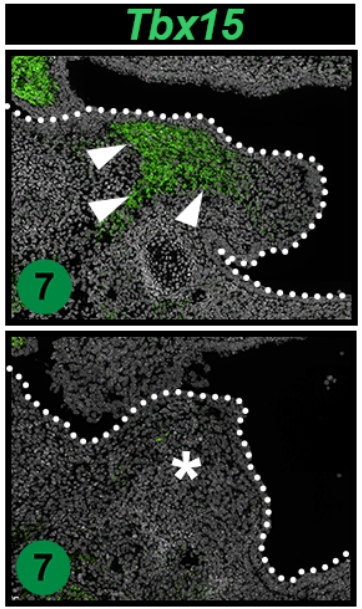


Chai Lab, unpublished

Spatial analysis identified location-specific molecular differences in control and mutant mice



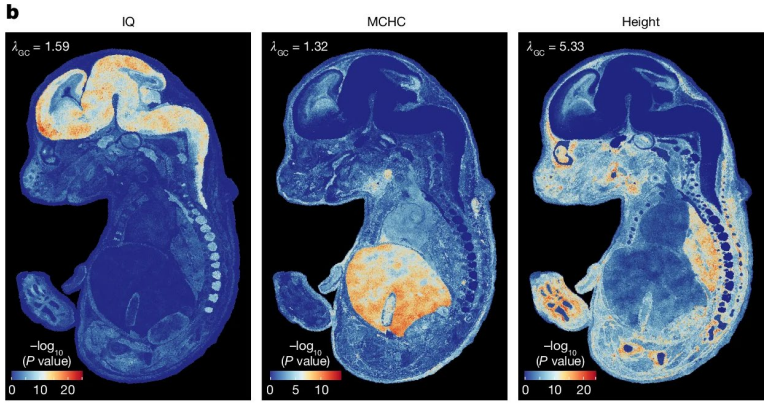




Chai Lab, unpublished

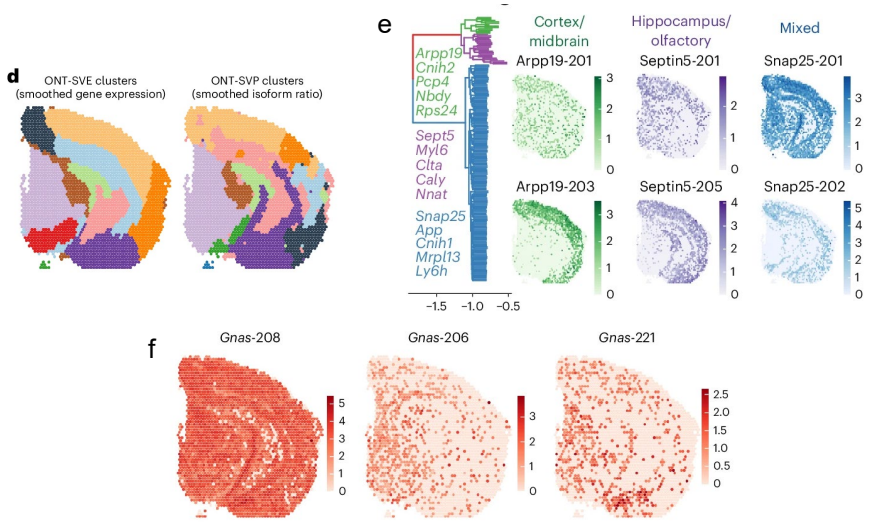
Emerging bioinformatics tools for craniofacial spatial genomics

Spatial mapping of GWAS data (gsMap)



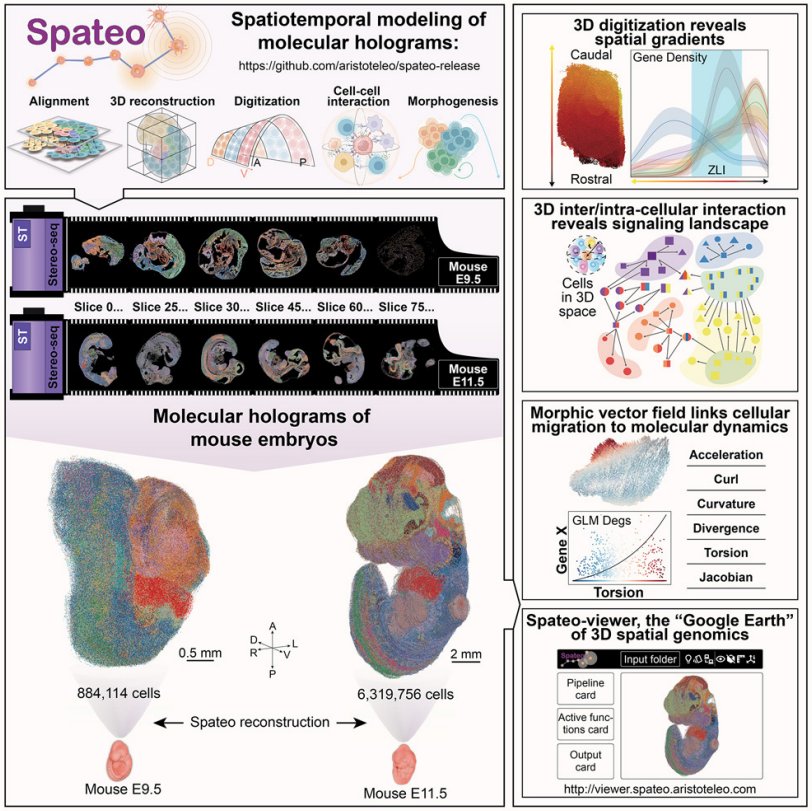
Song et al., Nature 2025

Isoform-resolution spatial pattern (SPLISOSM)



Su et al., Nat Biotechnol 2026

Next-generation spatial genomics approaches



Qiu et al., Cell 2024

Spatial Proteomics

PLATO, iPEX, DBiTplus, etc. enable multiplexed protein localization at single-cell resolution

Hu et al., Cell 2025; Wang et al., Nature 2026; Enninful et al., Nature Methods 2026;

Spatial Epigenomics

Spatial-ATAC-seq, SPACE-seq, SCA-seq, etc. map chromatin accessibility and enhancer-promoter contacts

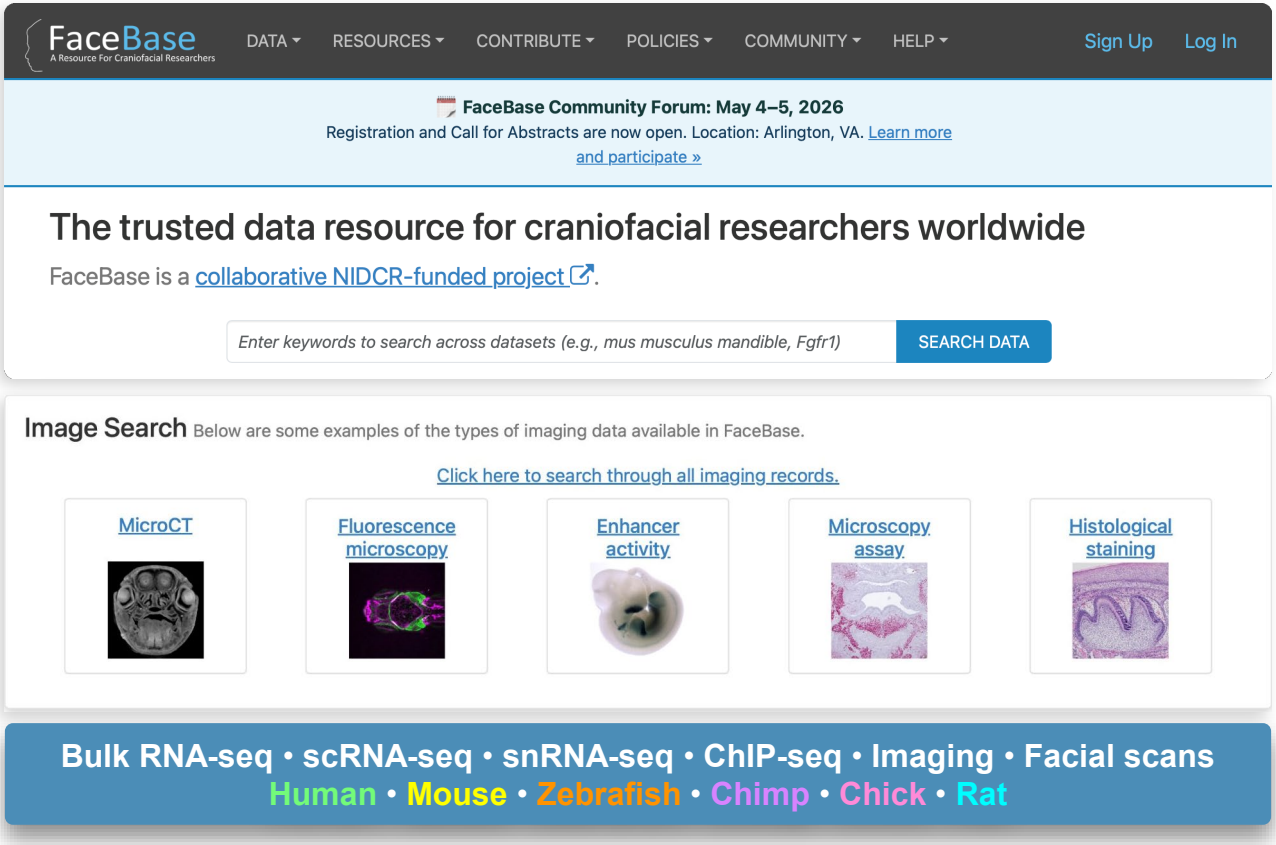
Deng et al., Nature 2022; Huang et al., PNAS 2025; Xie et al., eLife 2024,

Spatial Multi-Omics

DBiT-seq, Slide-tags, Spatial ATAC-RNA-seq, etc. co-profile epigenome, transcriptome, and proteome

Liu et al., Cell 2020; Russell et al., Nature 2024; Li et al., Naturel Protocols 2025

FaceBase hosts multi-modal datasets for dental, oral, craniofacial, and related systems research



FaceBase to serve as a hub for spatial genomics datasets related to the craniofacial region

1

Curated spatial genomic datasets

FaceBase + public repositories

2

Gene expression atlas

Quick spatial explorations on FaceBase

3

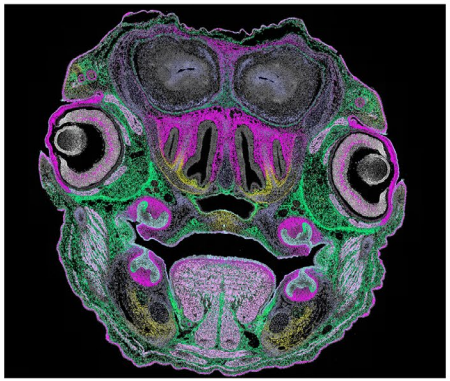
Direct raw data access

Download & comprehensive analysis

FaceBase provides a comprehensive *in vivo* gene expression atlas for craniofacial and related regions

- Coverage of craniofacial and related regions for dental, oral, and craniofacial research and beyond
- Multi-platform spatial transcriptomic datasets (seqFISH, Visium HD, and Stereo-seq)
- Large-scale *in vivo* gene expression profiling (~100–1,000 genes/cell)
- Anatomical structure-specific expression information for development- and disease-associated genes

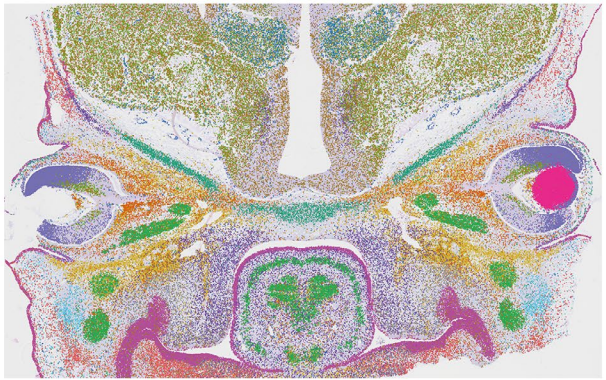
seqFISH



E12.5 · E13.5 · E15.5
Mouse Head

Feng et al., Nat Commun 2025 — seqFISH

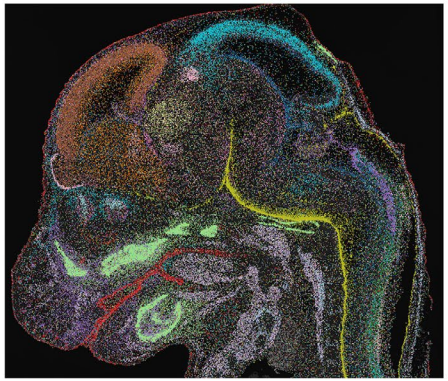
Visium HD



E12.5 · E13.5
Mouse Palate

Piña et al., Sci Rep 2025 — Visium HD

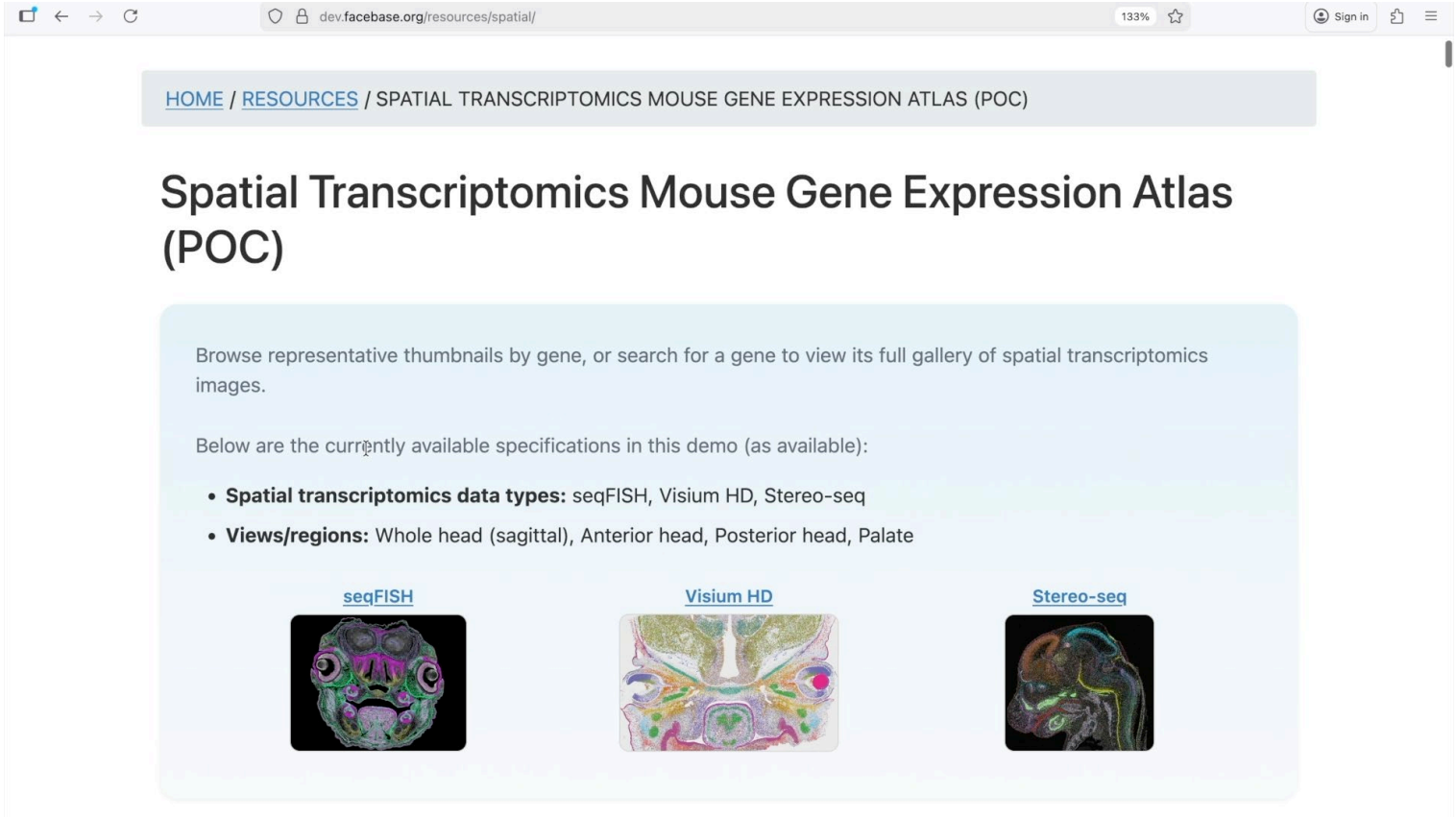
Stereo-seq



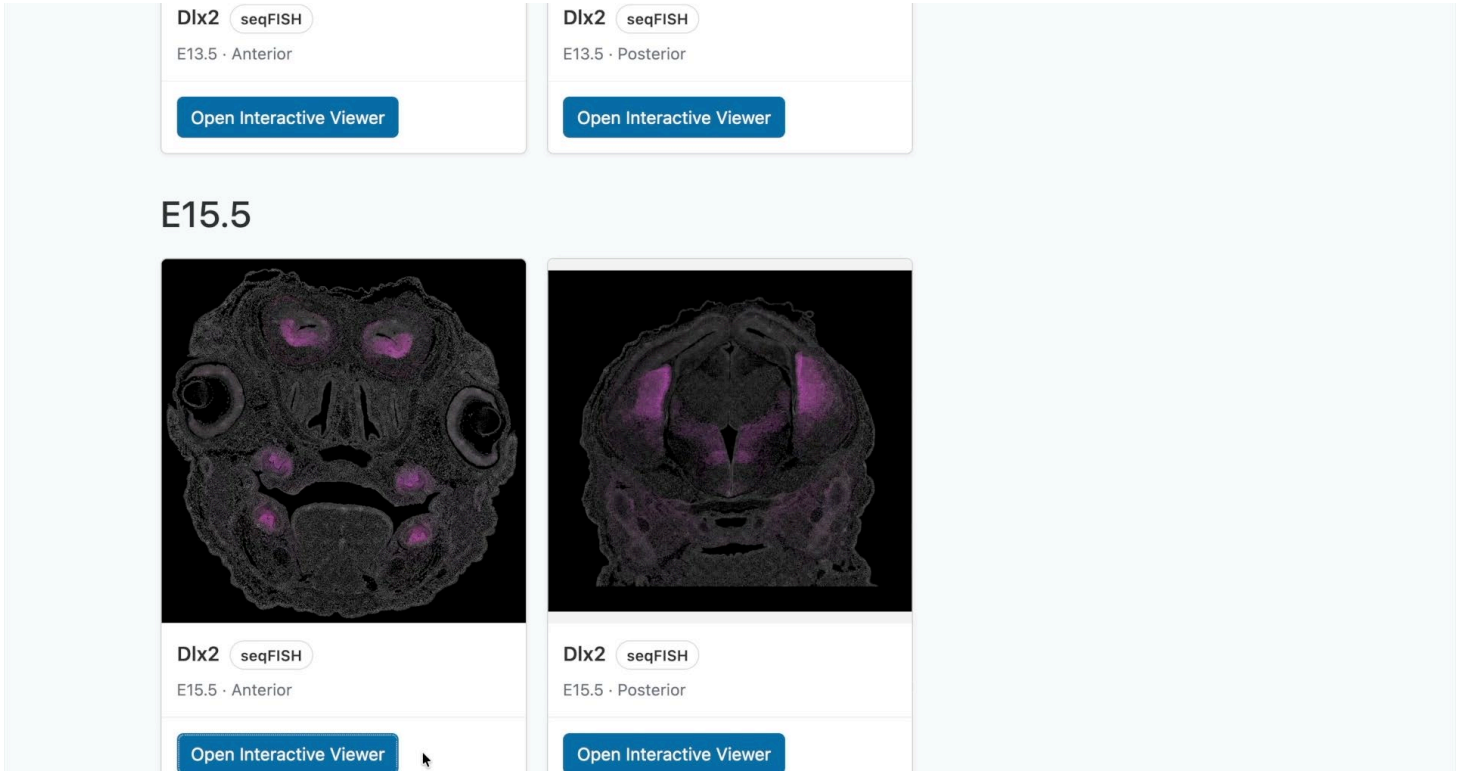
E12.5 · E14.5 · E16.5
Mouse Head

Chen et al., Cell 2022 — Stereo-seq

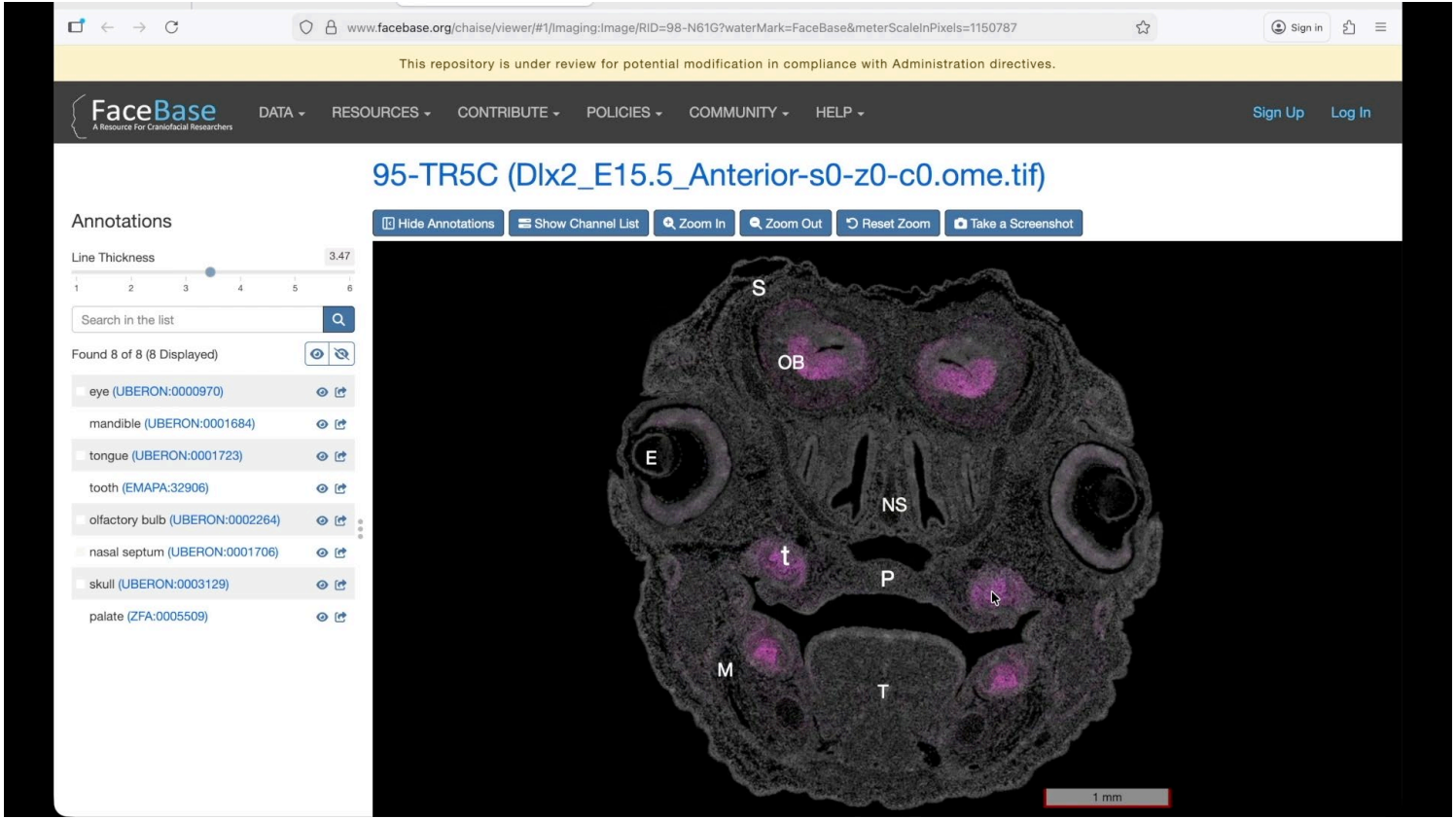
Spatial gene expression atlas with intuitive interface and one-click access



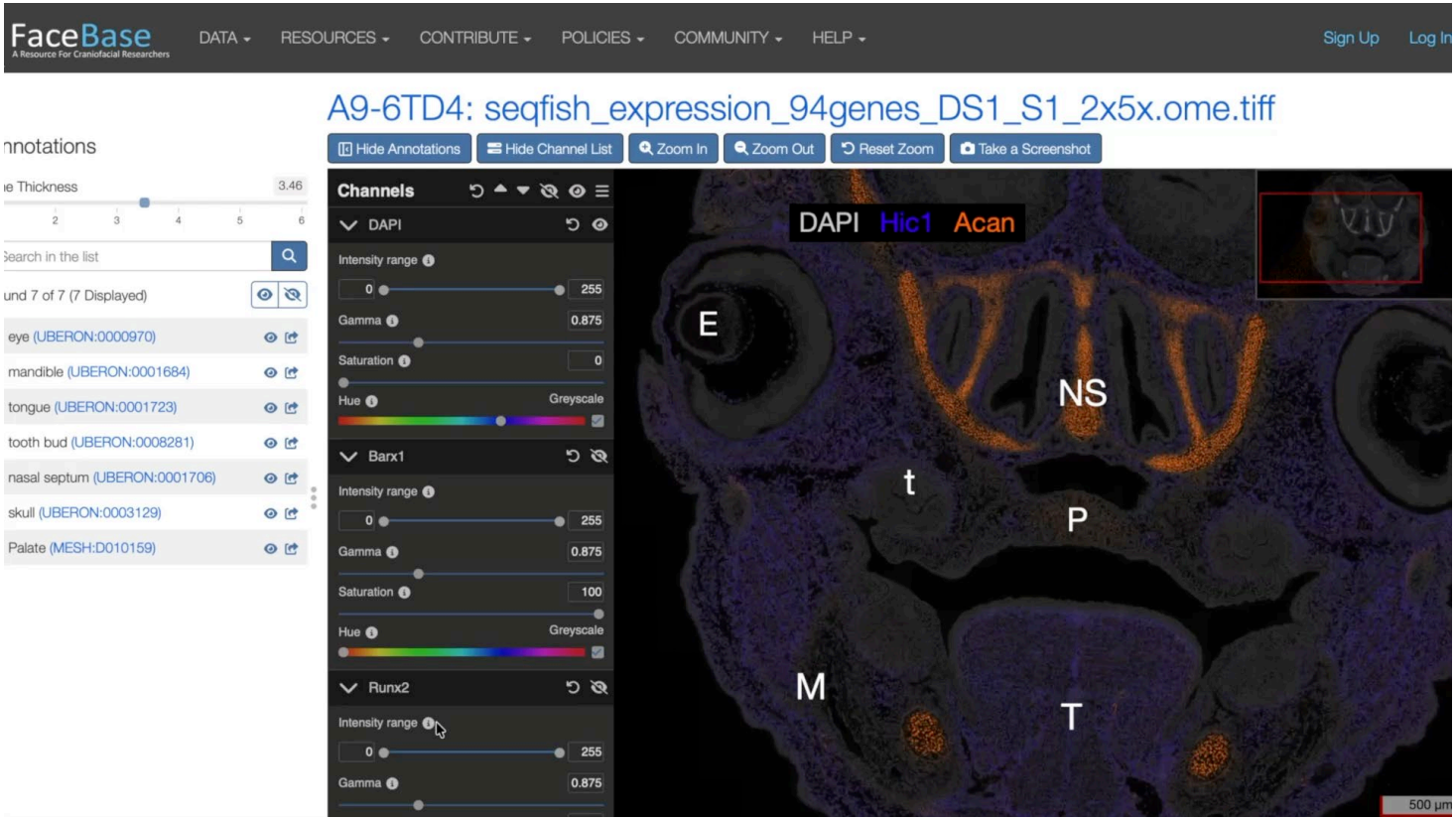
Interactive visualization of spatial gene expression patterns associated with anatomical locations



Analyze spatial gene expression levels across cells in the craniofacial region



Upcoming feature:
multi-channel viewer for simultaneous visualization of whole gene panels



FaceBase spatial gene expression atlas release at FaceBase Forum, May 4–5

FaceBase Community Forum

May 4–5, 2026

USC/ISI East Office · Arlington, VA

In person or remote

🌐 www.facebase.org

✉ help@facebase.org

Summary

Spatial genomics bridges gene expression to anatomy, uncovering location-specific molecular and cellular changes that are undetectable by conventional methods.

Acknowledgements

Chai Lab

USC University of Southern California

Funding: NIDCR/NIH (R01DE012711 and U24DE034163 to Yang Chai)