A fluorescence microscopy image of a zebrafish skull. The image shows a complex network of green and red fluorescent structures, likely representing different tissues or cells involved in skull development. The green structures form a dense, interconnected network, while the red structures are more localized and appear as distinct, elongated shapes. The background is dark, highlighting the fluorescent signals.

Anatomical atlas and transgenic toolkit for late skull development in zebrafish

Shannon Fisher
Matthew Harris

A fluorescence microscopy image showing a biological specimen. The image displays a complex network of green and red signals against a dark background. The green signal appears as a dense, interconnected web of fibers or structures, while the red signal highlights specific, elongated, and somewhat linear features. The overall appearance is that of a highly detailed, multi-colored biological structure, possibly a cell or tissue section.

Fisher lab

Michelle Kanther
Erika Kague
Lexy Stanley

Harris lab

Katrin Henke
Michael Brent Hawkins

Collaboration uCT quantitation

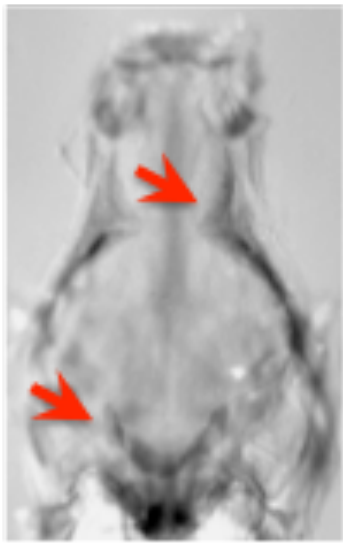
Julia Charles
Antonios Aliprantis
Jeffrey Duryea

How do you build a fish skull?

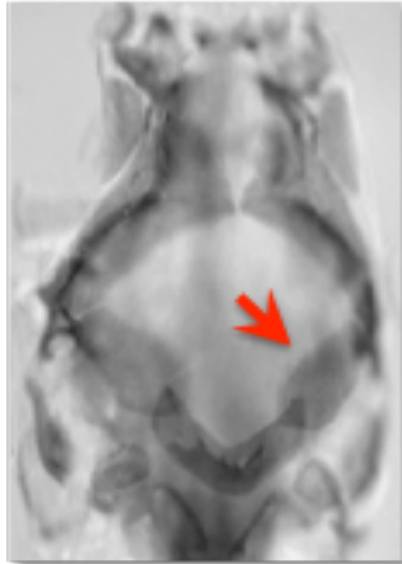
Integrated approach to describe zebrafish skull formation

- Anatomic and molecular description of normal process
- Comparison to mutants
- Comparison to other species

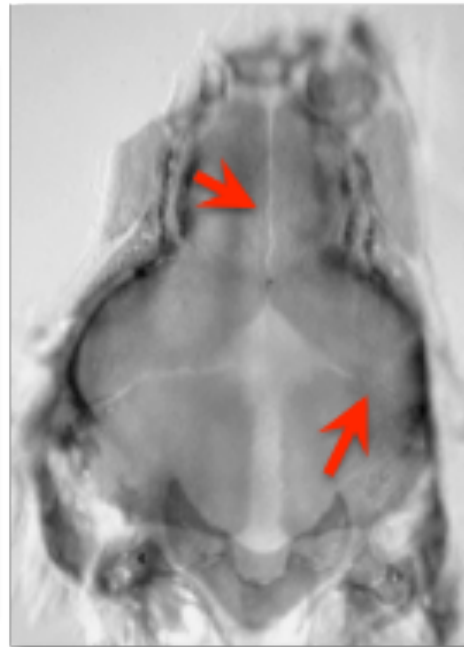
Post-larval development of the cranial vault



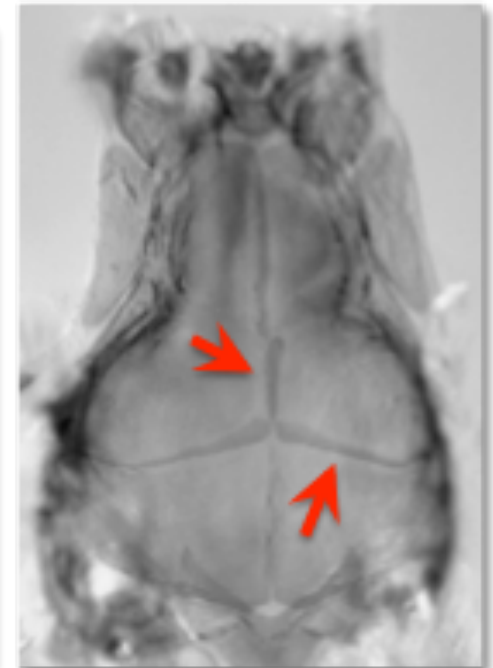
6.5 mm SL



9 mm SL



11 mm SL

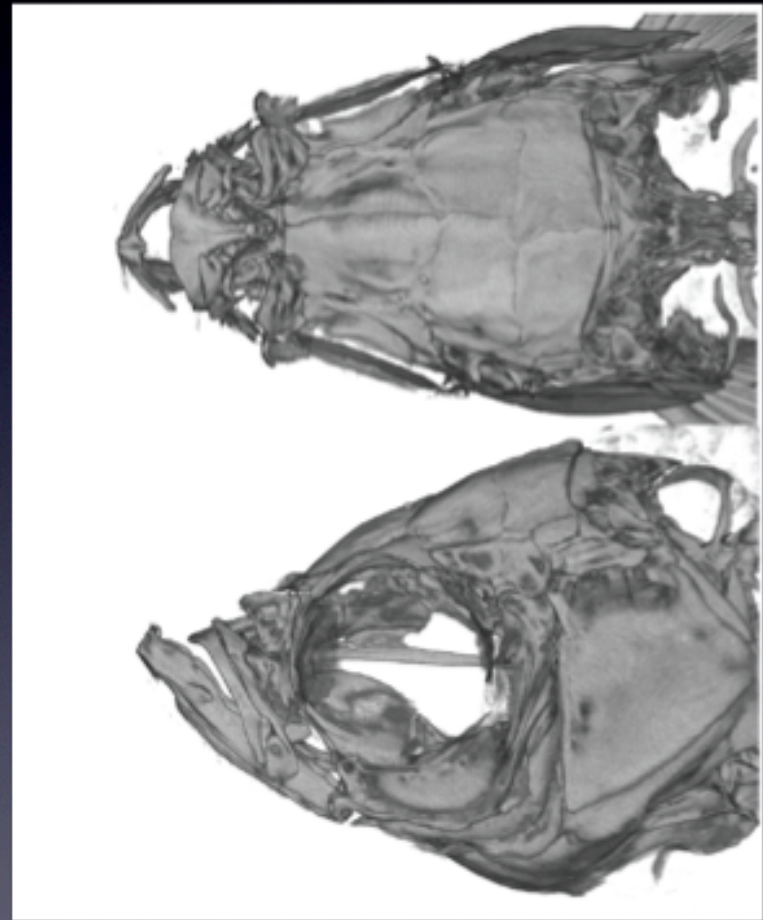
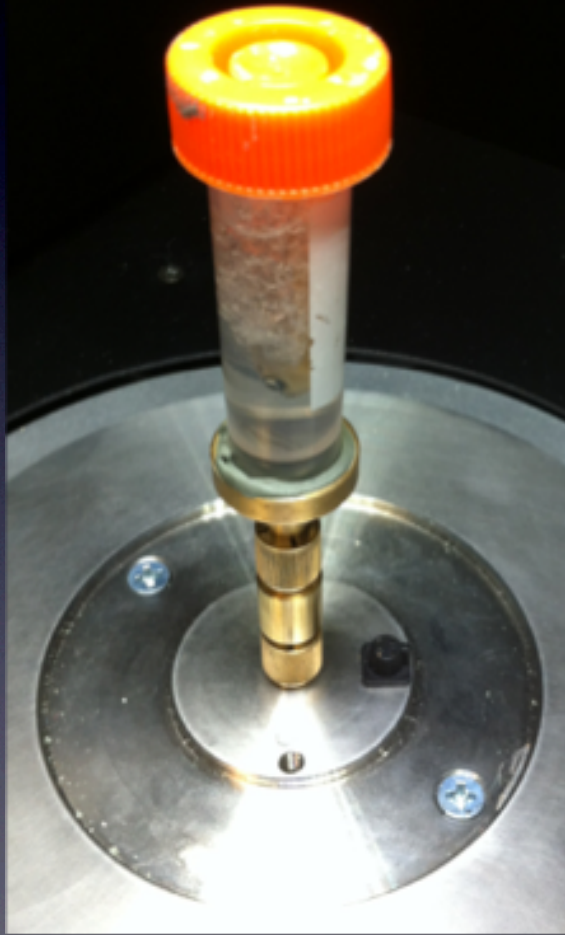


13.5 mm SL

SL = standard length

6.5 mm ~ 2.5-3 weeks, 13.5 mm ~ 6 weeks

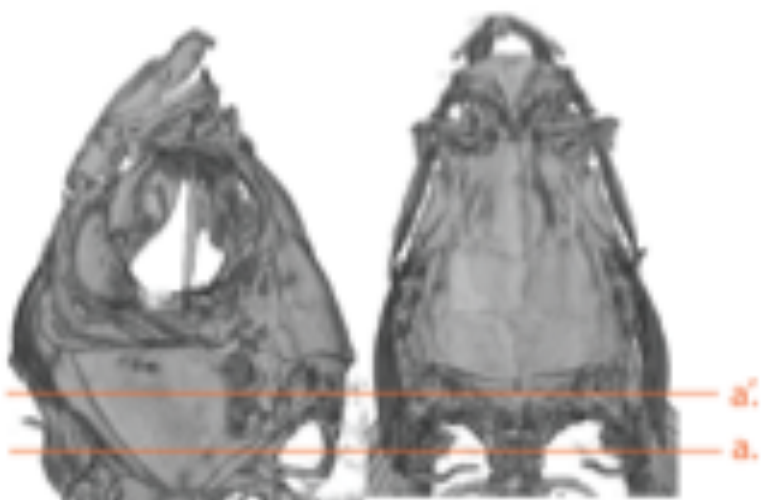
Detailed archived anatomy of the adult zebrafish skull: microcomputed tomography (μ CT)



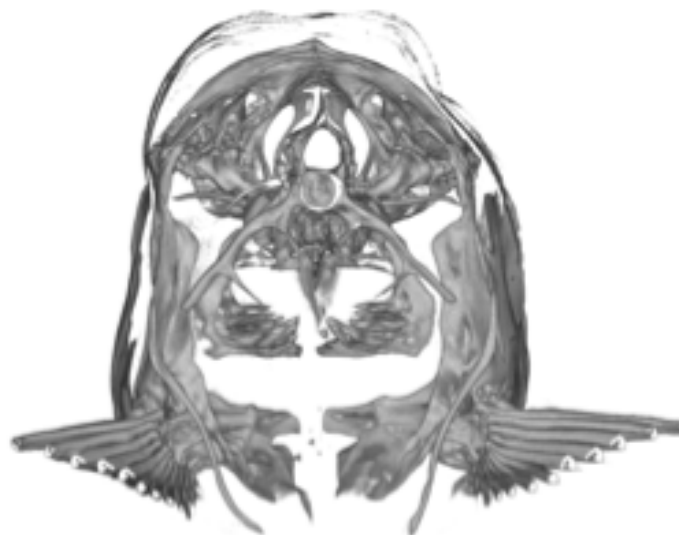
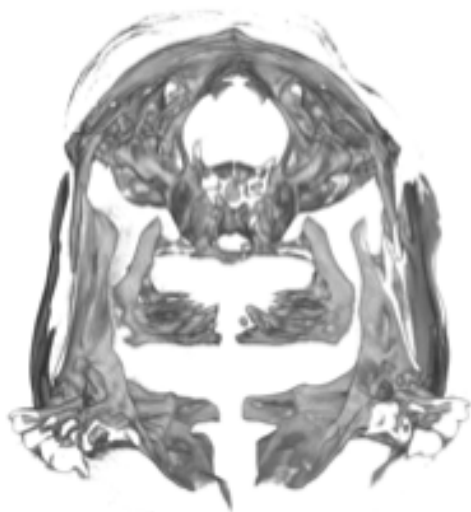
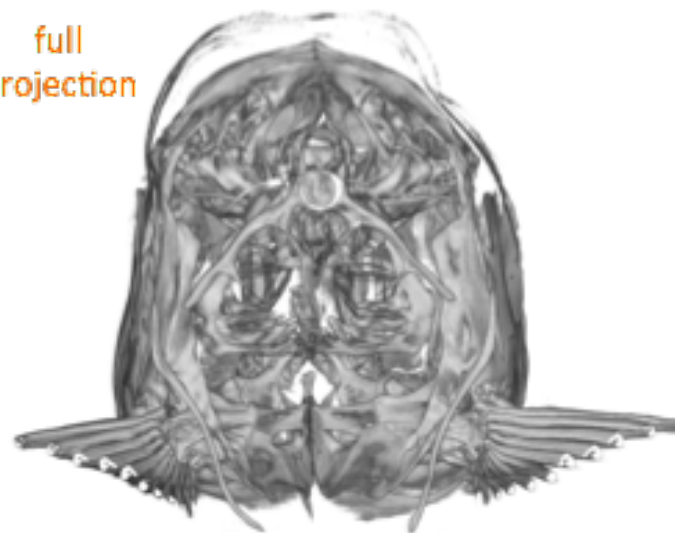
Visualization of complex form



Ability to dissect complex anatomy *in silico*

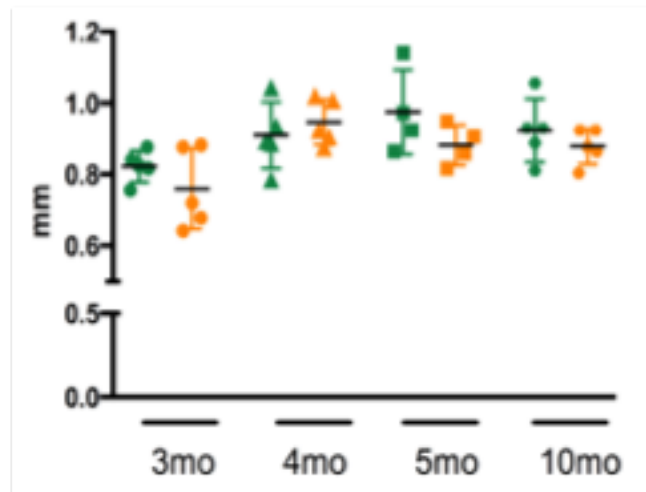
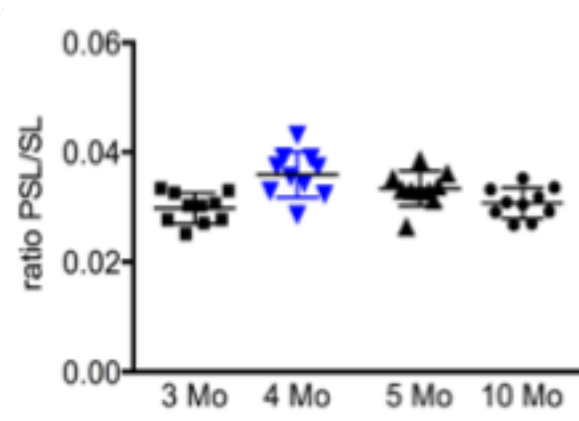
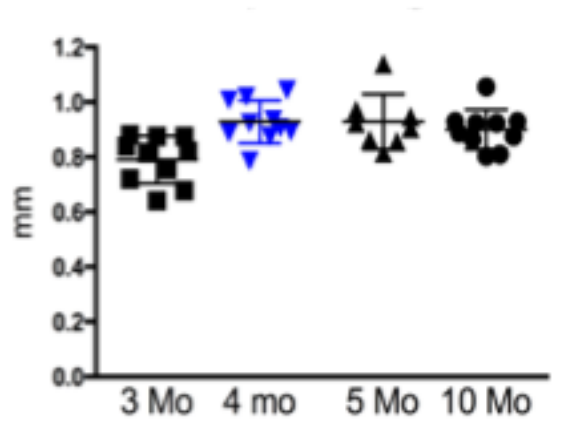
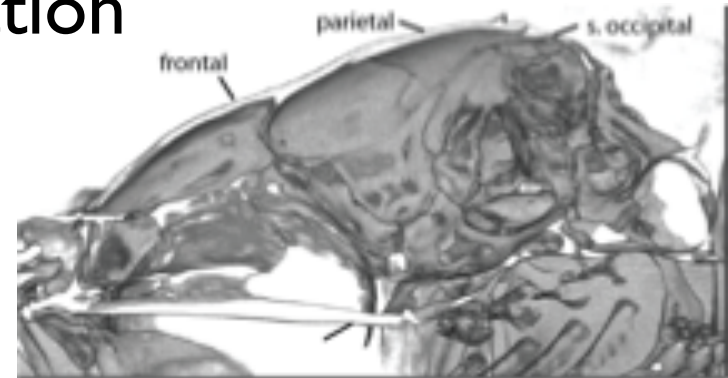


full
projection



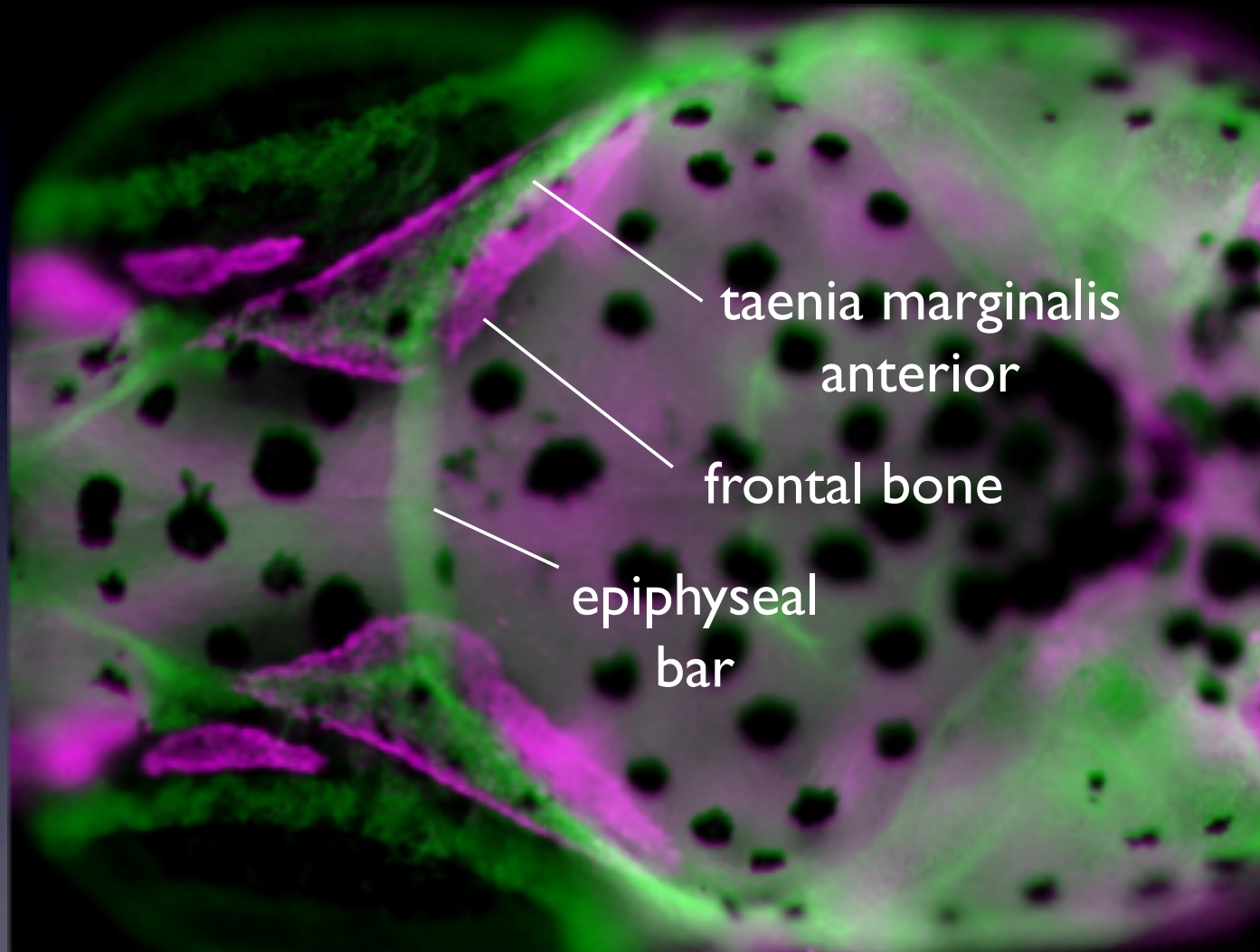
Standardization to minimize variation

Effects of rearing, age, and genetic variation



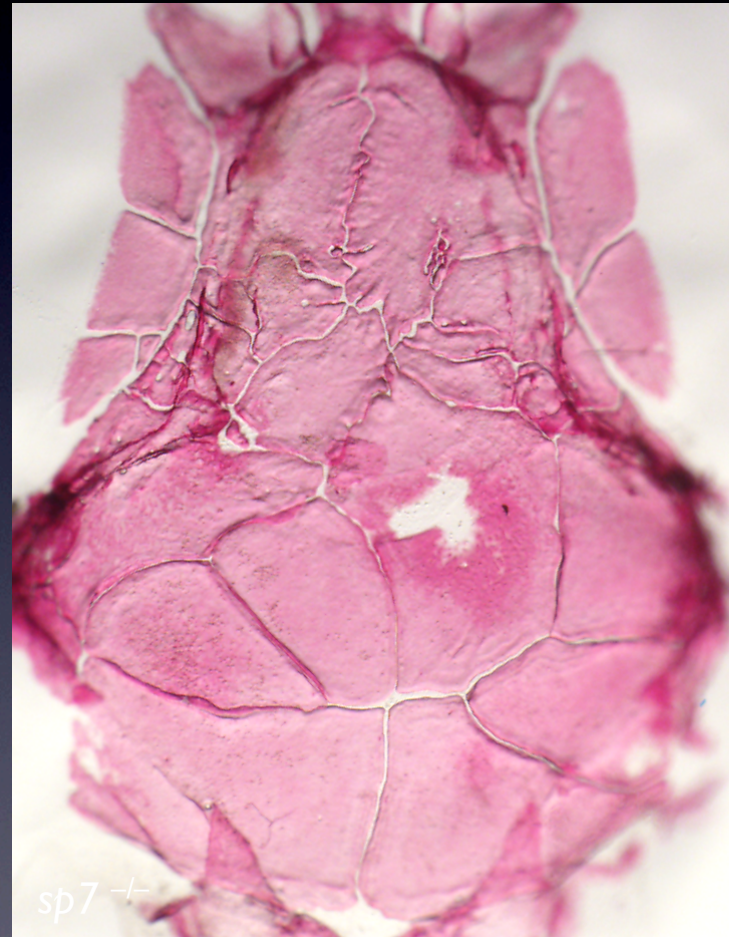
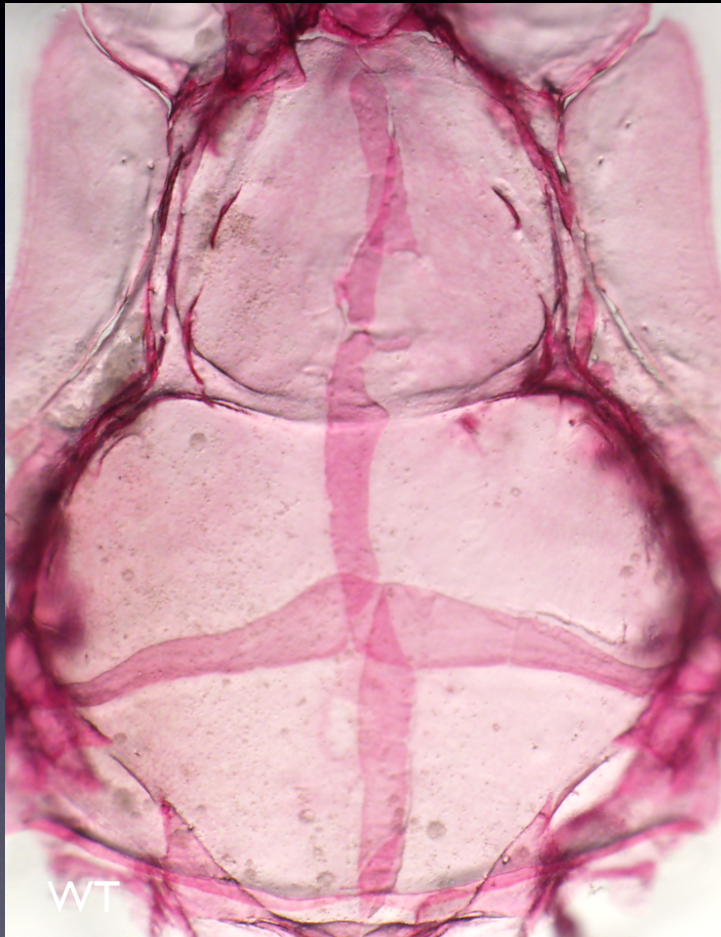
Julia Charles
Katrin Henke

Dynamic imaging of the post-larval skeleton

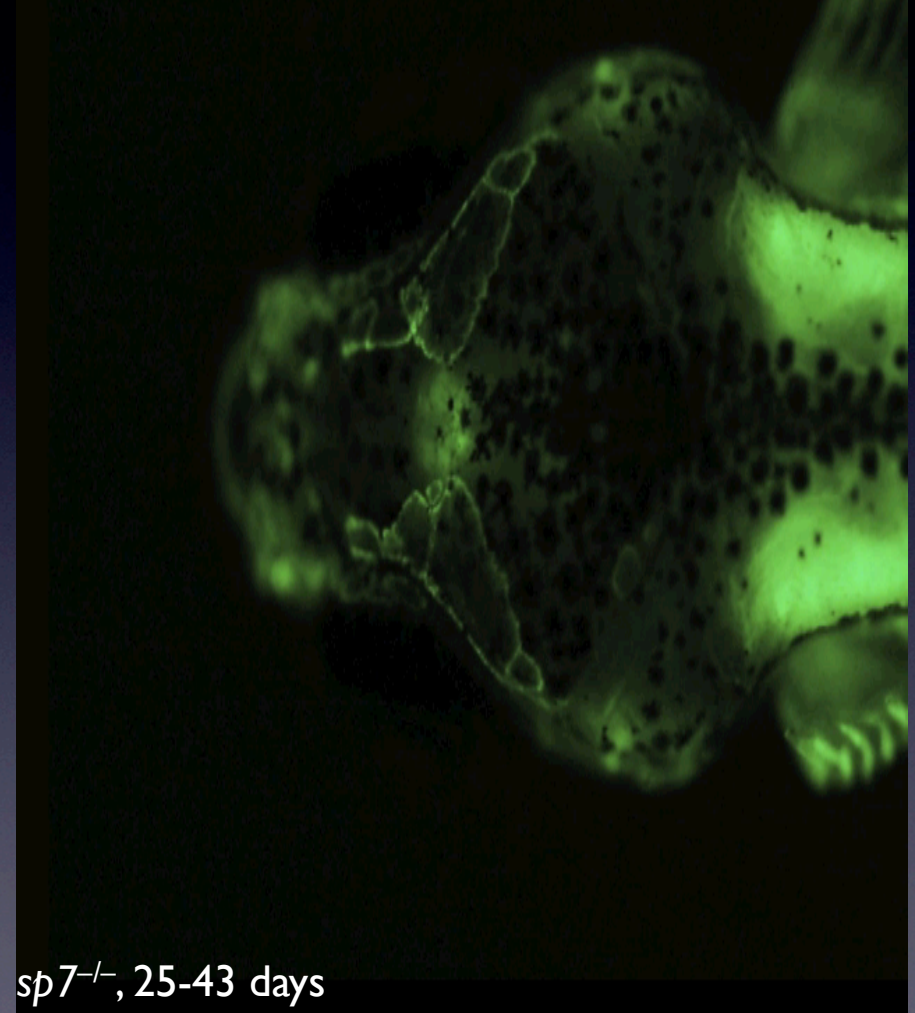
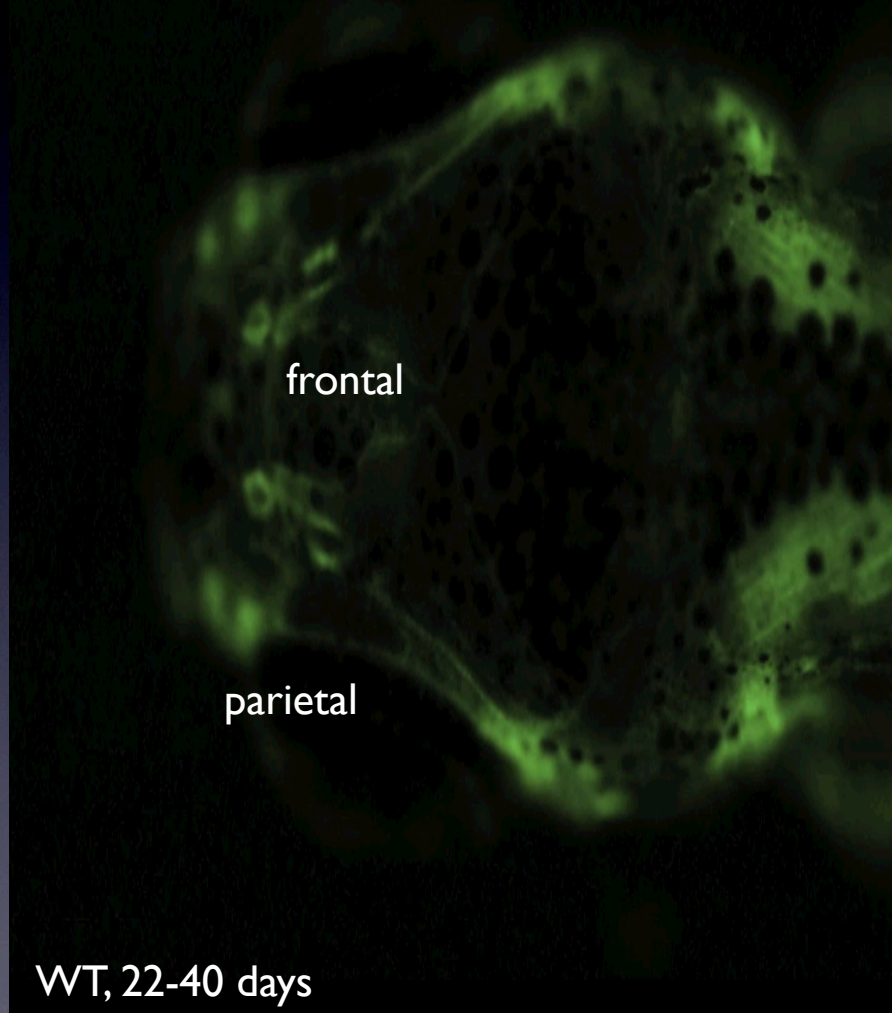


collal:egfp *sp7:mcherry*

Loss of general osteoblast gene *sp7* causes severe skull patterning defects



Ectopic skull bones grow separately and fail to form overlapping sutures



RUNX2:egfp (early osteoblasts)

Erika Kague

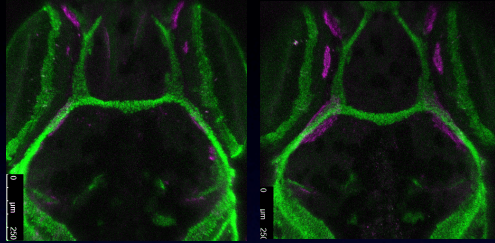
Leica TSI LCS macro confocal



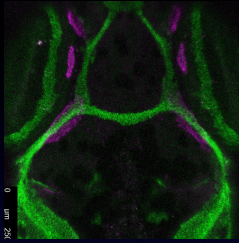
Sequential confocal imaging of skull formation

coll1a1:egfp *sp7:mcherry*

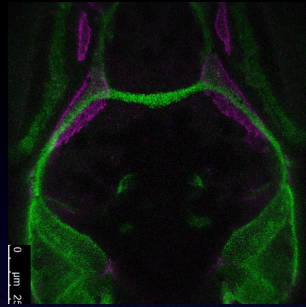
Michelle Kanther



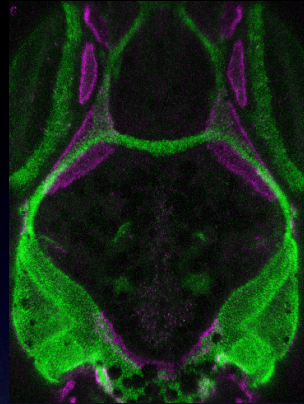
18 dpf



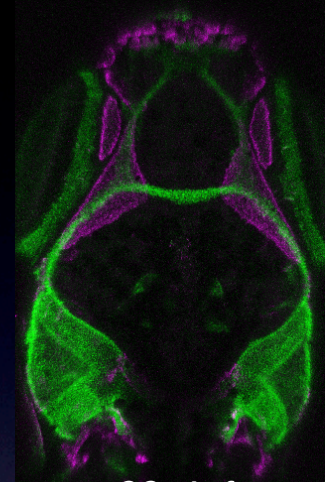
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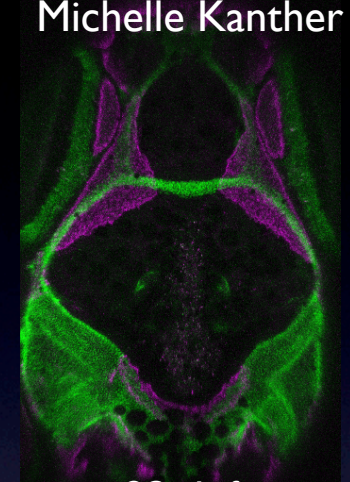
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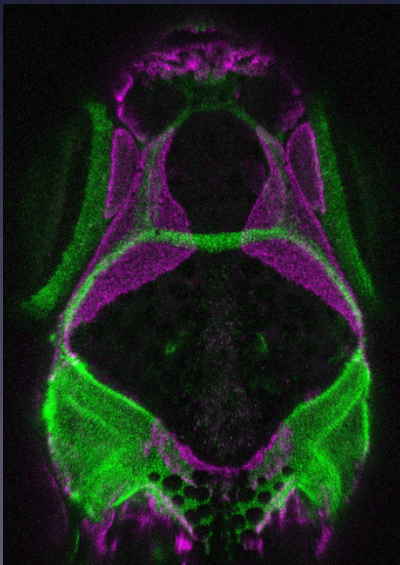
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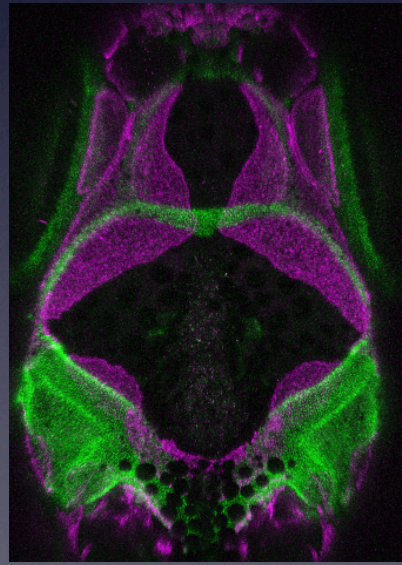
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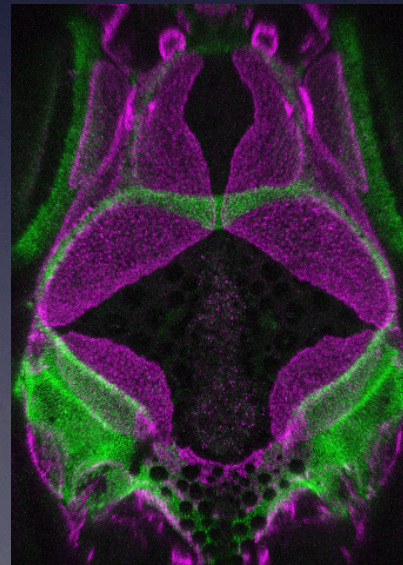
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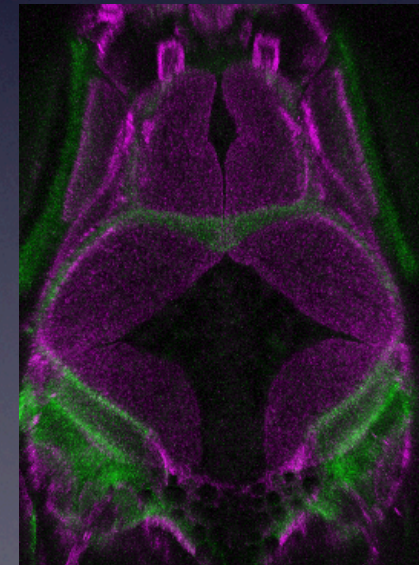
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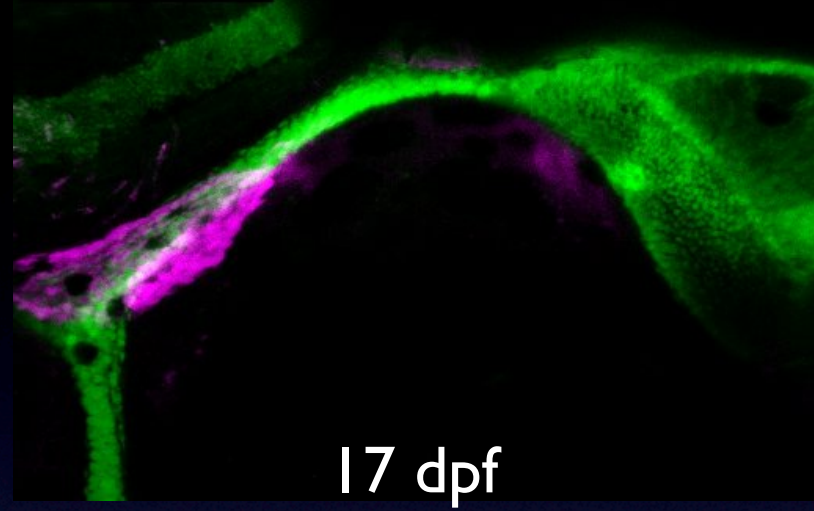
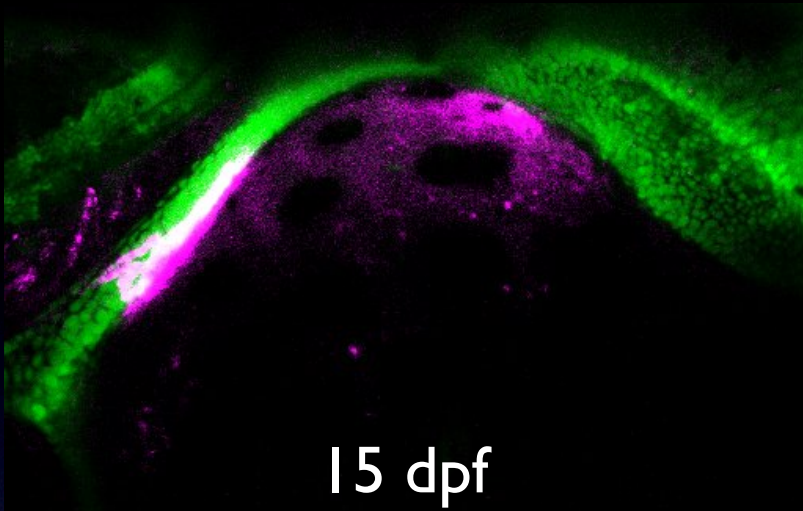
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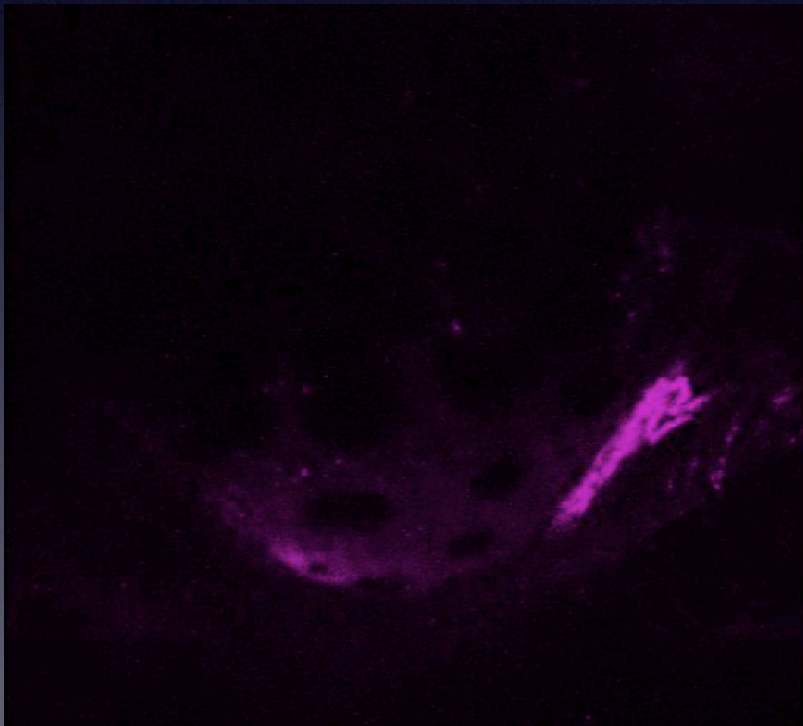
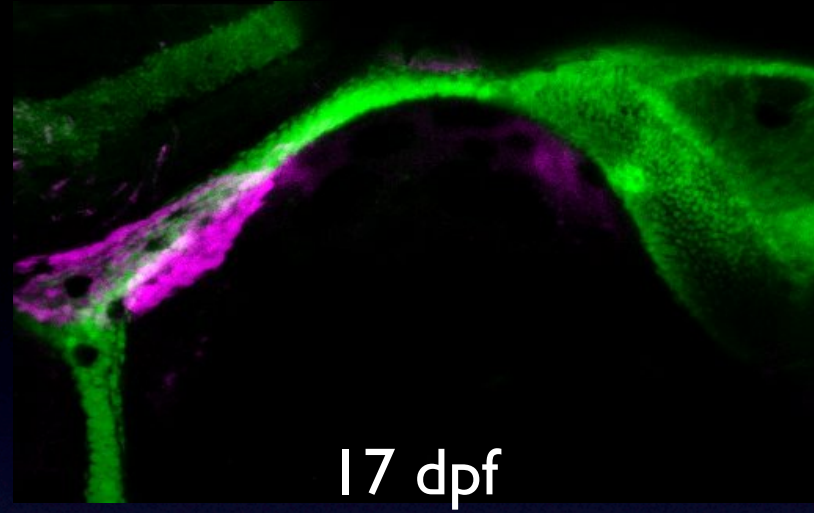
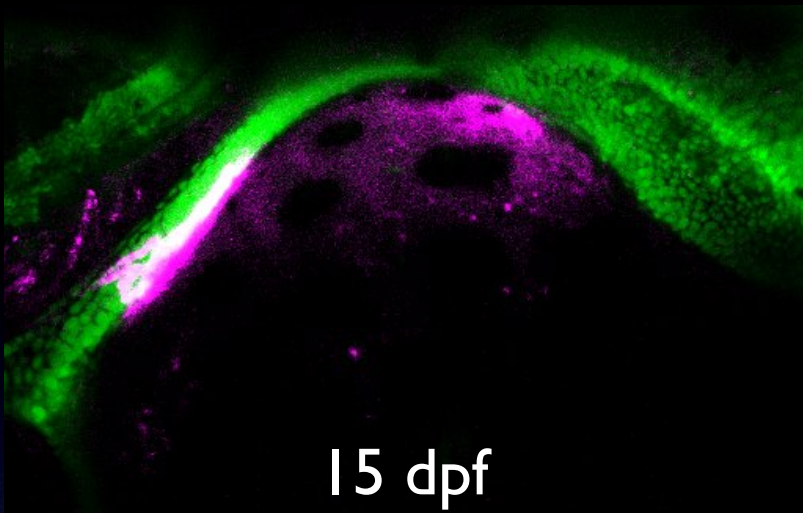


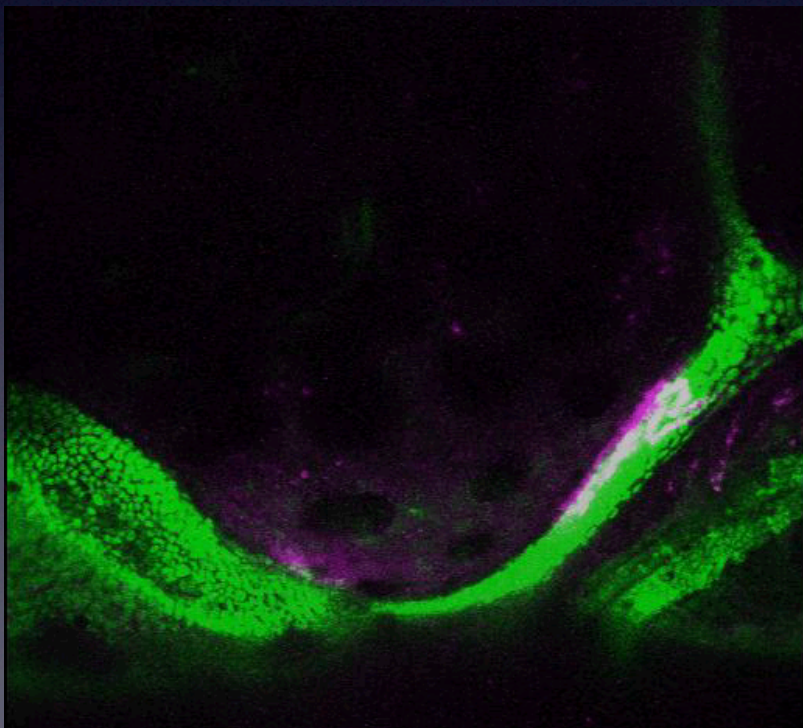
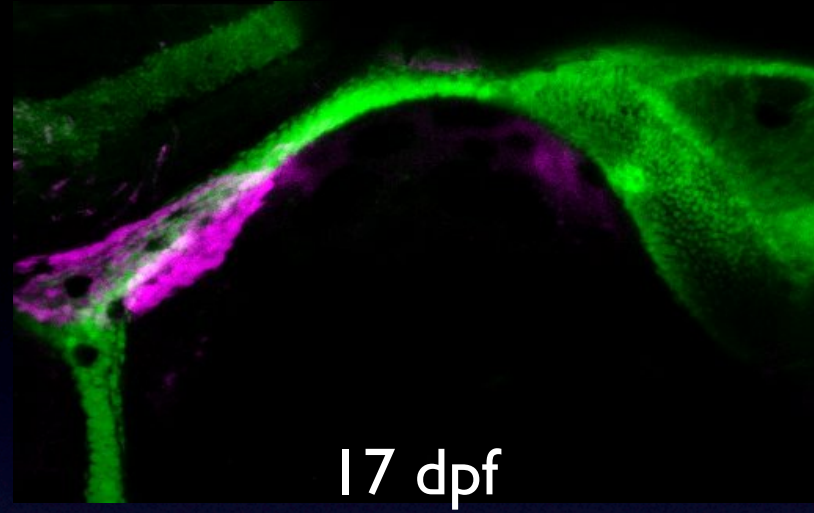
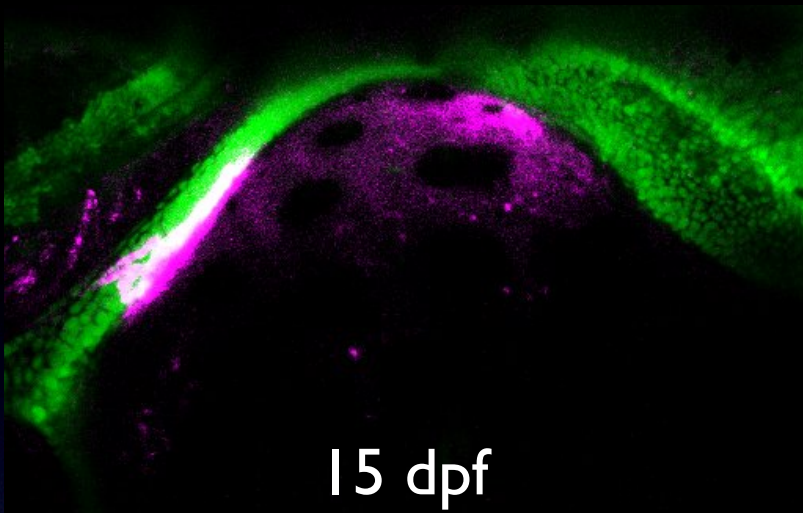
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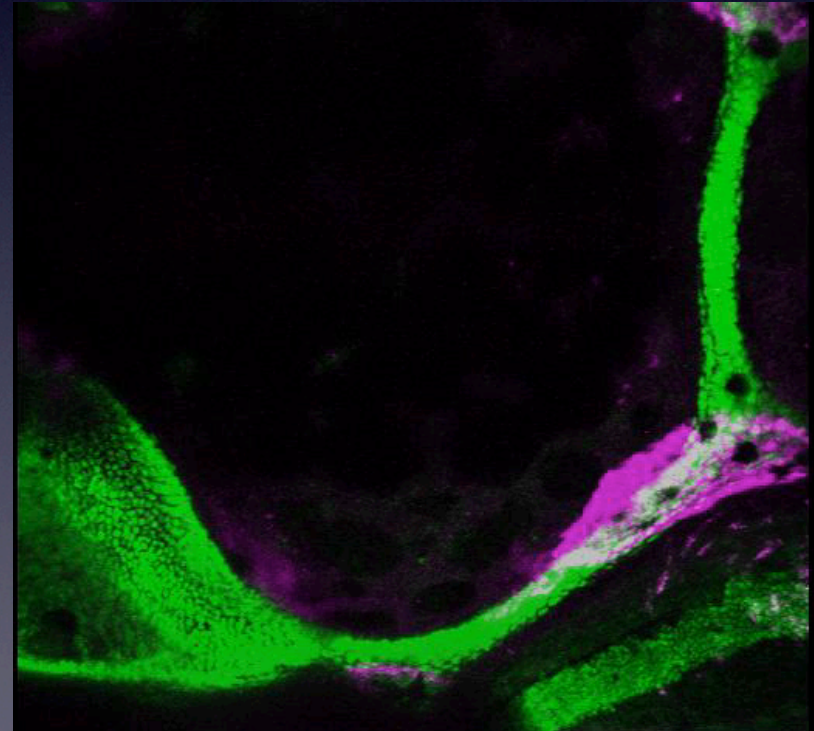
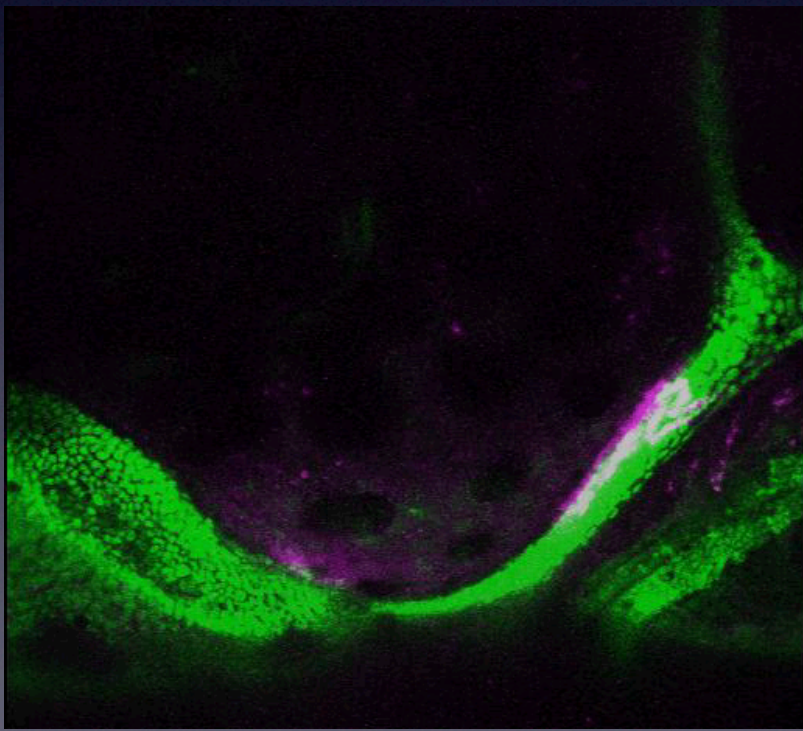
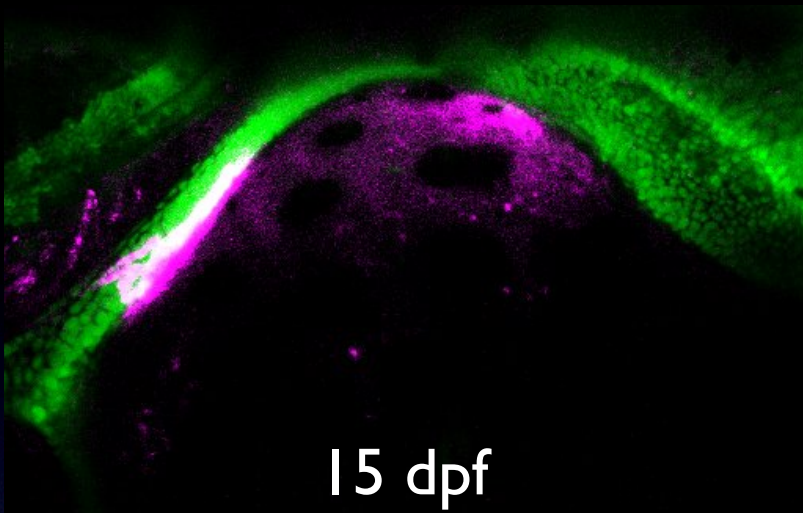


32 dpf

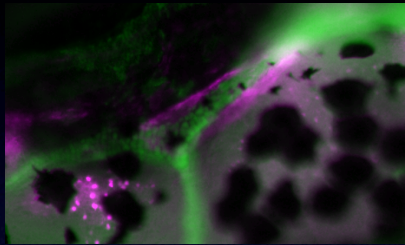




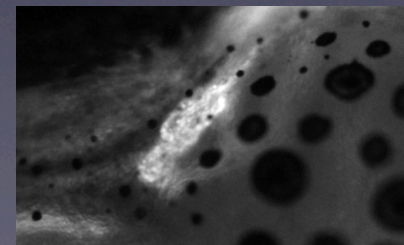
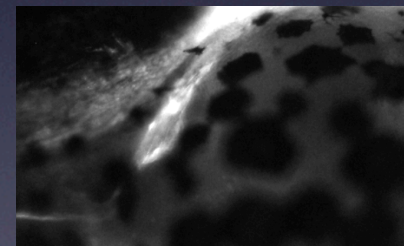
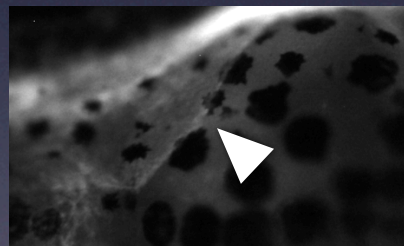
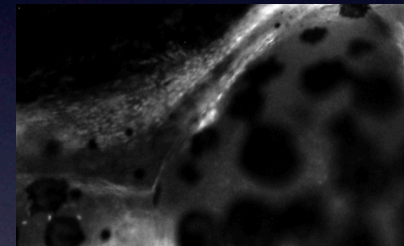
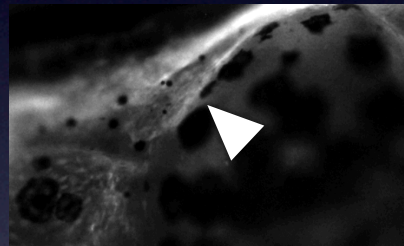
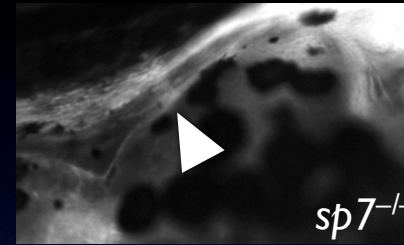
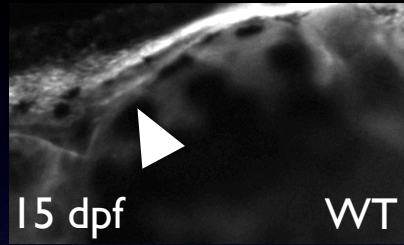




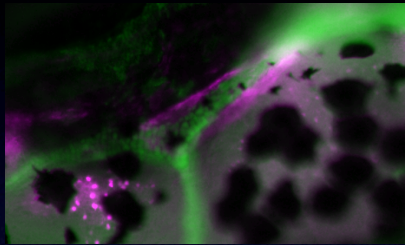
Ectopic bones form shortly after frontal bone initiation



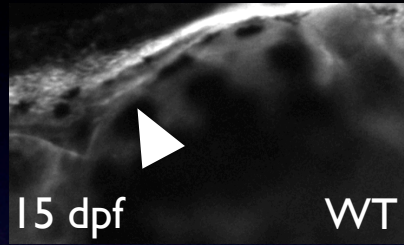
col1a1:egfp
RUNX2:mcherry



Ectopic bones form shortly after frontal bone initiation

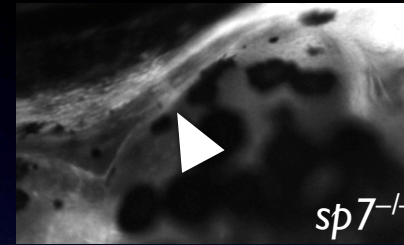


col1a1:egfp
RUNX2:mcherry

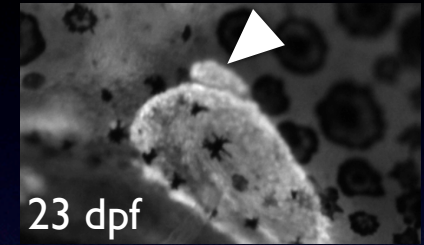


15 dpf

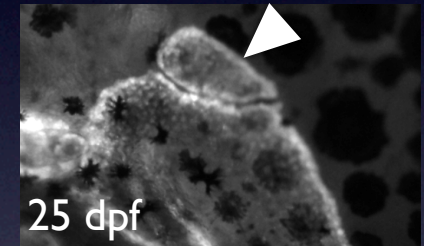
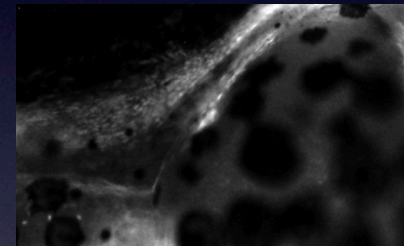
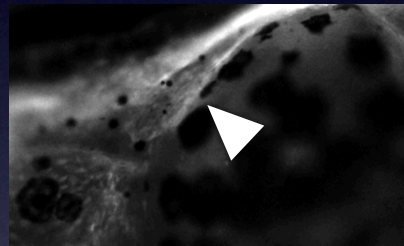
WT



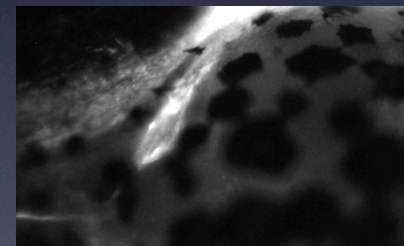
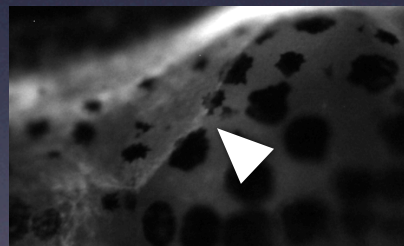
sp7^{-/-}



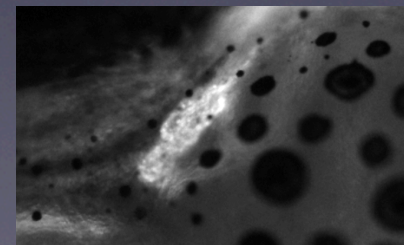
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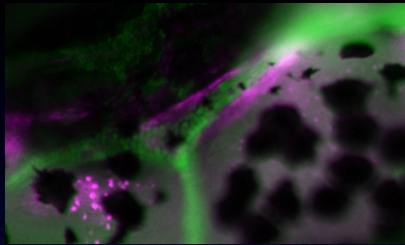
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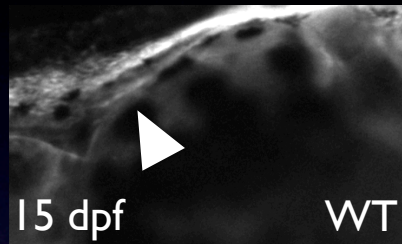
21 dpf



Ectopic bones form shortly after frontal bone initiation

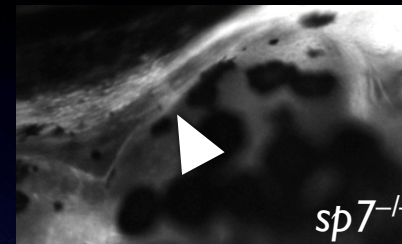


col1a1:egfp
RUNX2:mcherry

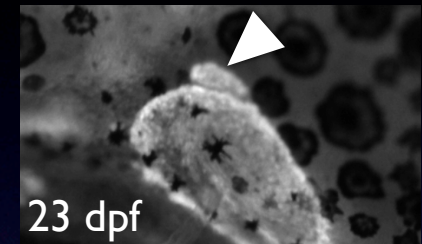


15 dpf

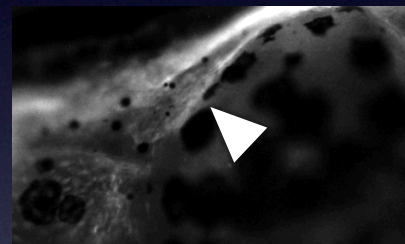
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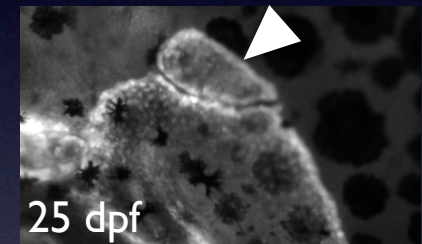
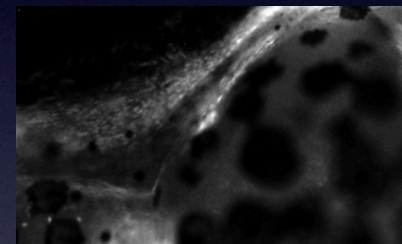
sp7^{-/-}



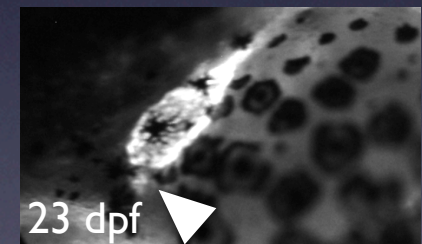
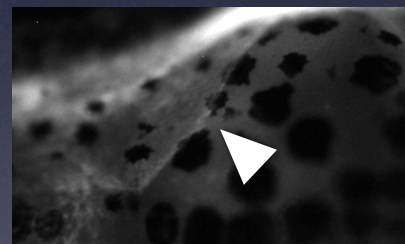
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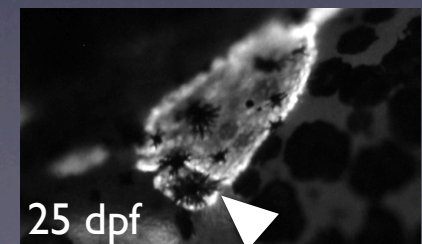
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25 dpf



23 dpf

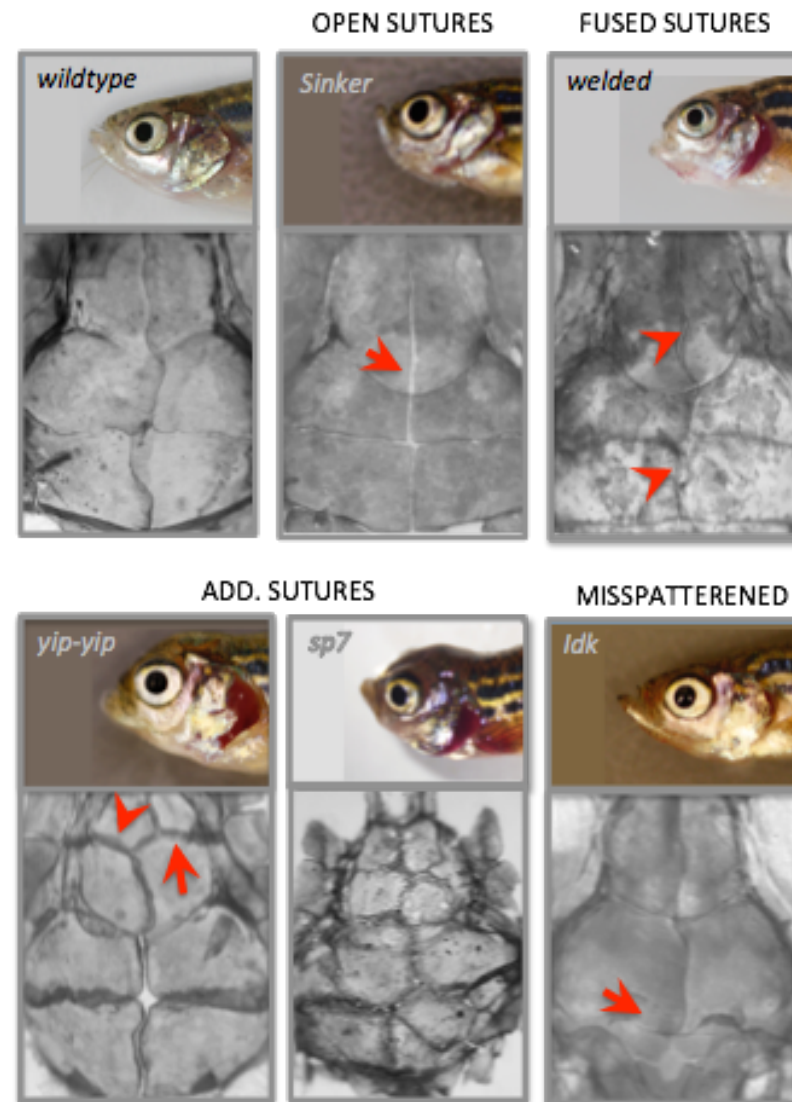
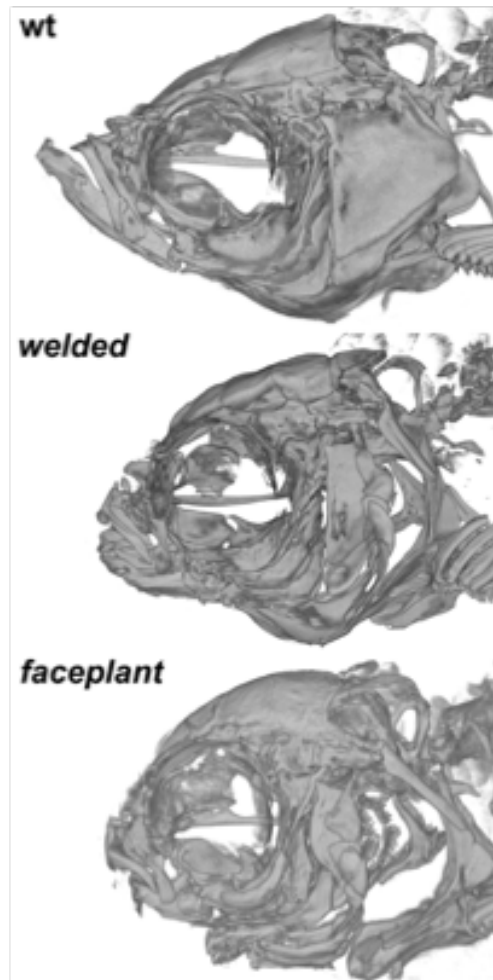


25 dpf

Dynamic imaging of skull development

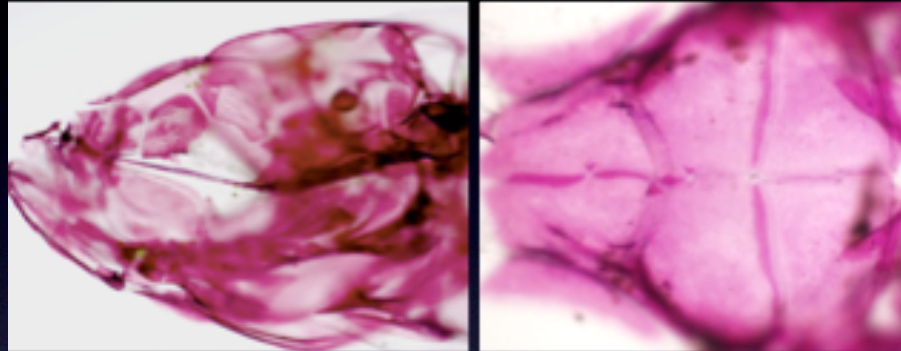
- Frontal bone initiates in close contact with cartilage
- Initial lag followed by rapid planar growth
- Hypothesize three phases of frontal bone formation
 - Initiation - similar to endochondral bone formation?
 - Planar, directional growth (BMP signaling)
 - Overlapping to form sutures - signals between bones?

Zebrafish mutants display abnormalities in multiple aspects of skull formation

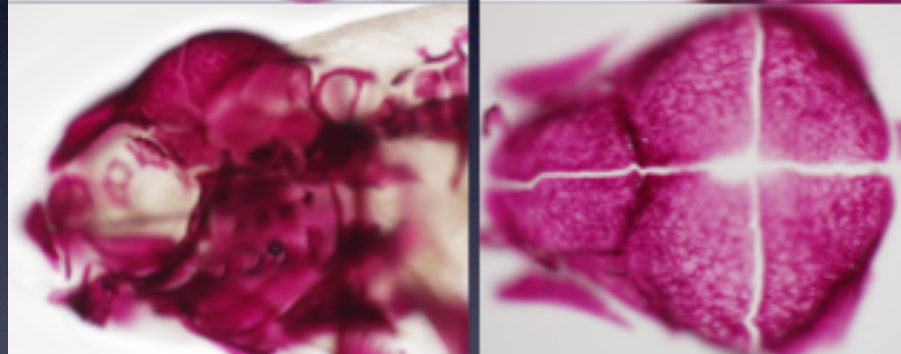


Mutations in *toth* and *lubber* lead to non-overlapping sutures

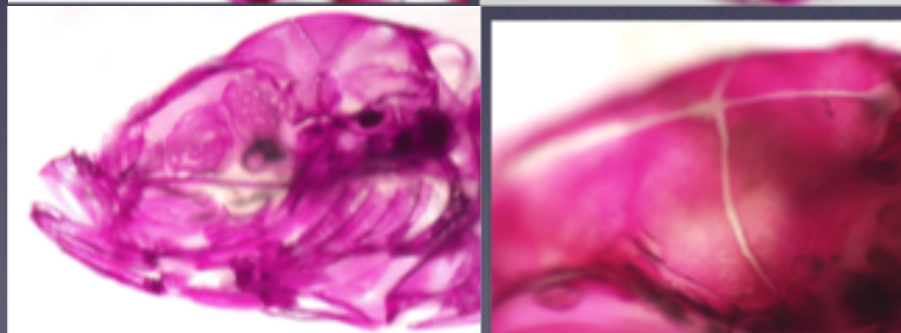
WT



toth^{-/-}



lubber^{-/-}



Short-term goals

- Integrate approaches
 - Expand period of time where both approaches work
 - Confocal on later stages, fixed samples
 - Sensitizing μ CT to work on smaller fish
 - Fix transgenic fish for μ CT
 - Image same mutants with both approaches
- Prepare WT data for upload
- Make first set of transgenic lines, plasmids available

Longer-term issues to resolve

- How to best analyze and present data
 - Confocal stacks in universal format
 - Same for μ CT data?
 - Isosurface rendering for confocal data, with annotation
- Comparisons to other species
 - Ontology cannot be unified! (22 vs. 78 bones)
- Alternatives to strict anatomical ontology
 - Developmental homology
 - Functional equivalence