Mechanoadaptation of epithelial tissues to dynamic curvature

Rémi Tranzer[1], Marine Luciano[1] and Sylvain Gabriele[1]*

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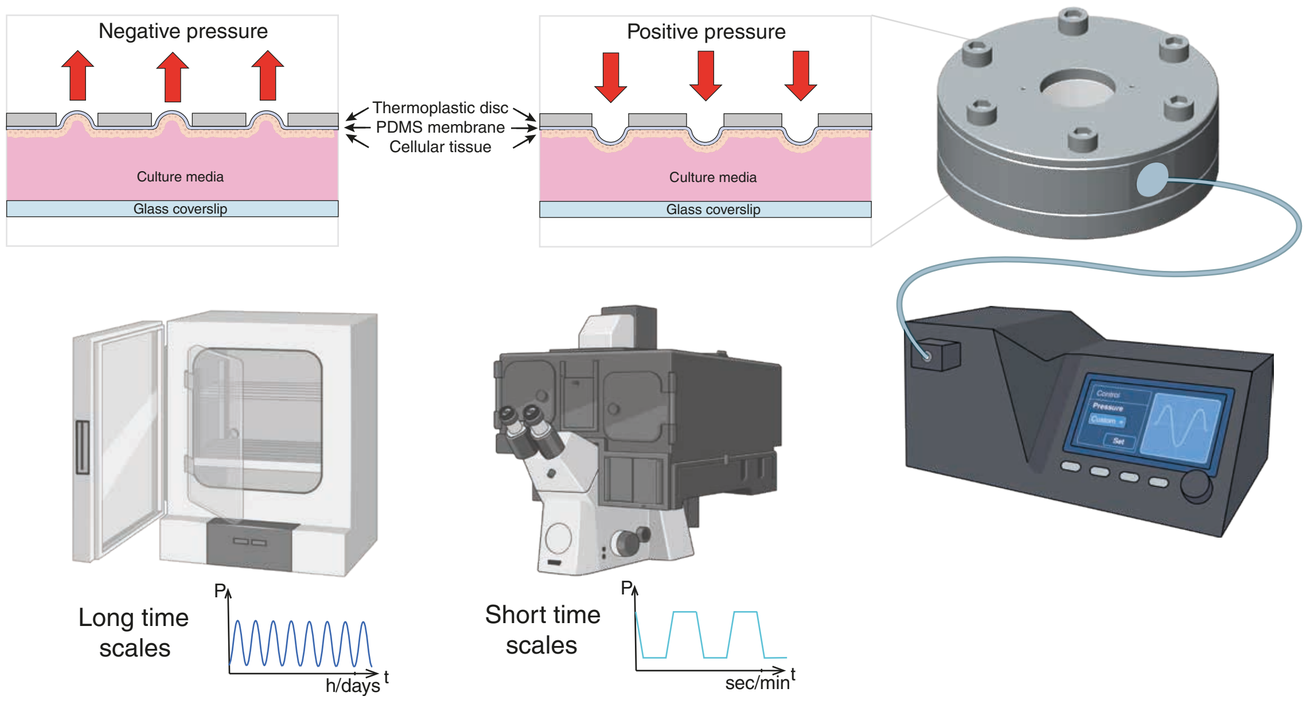
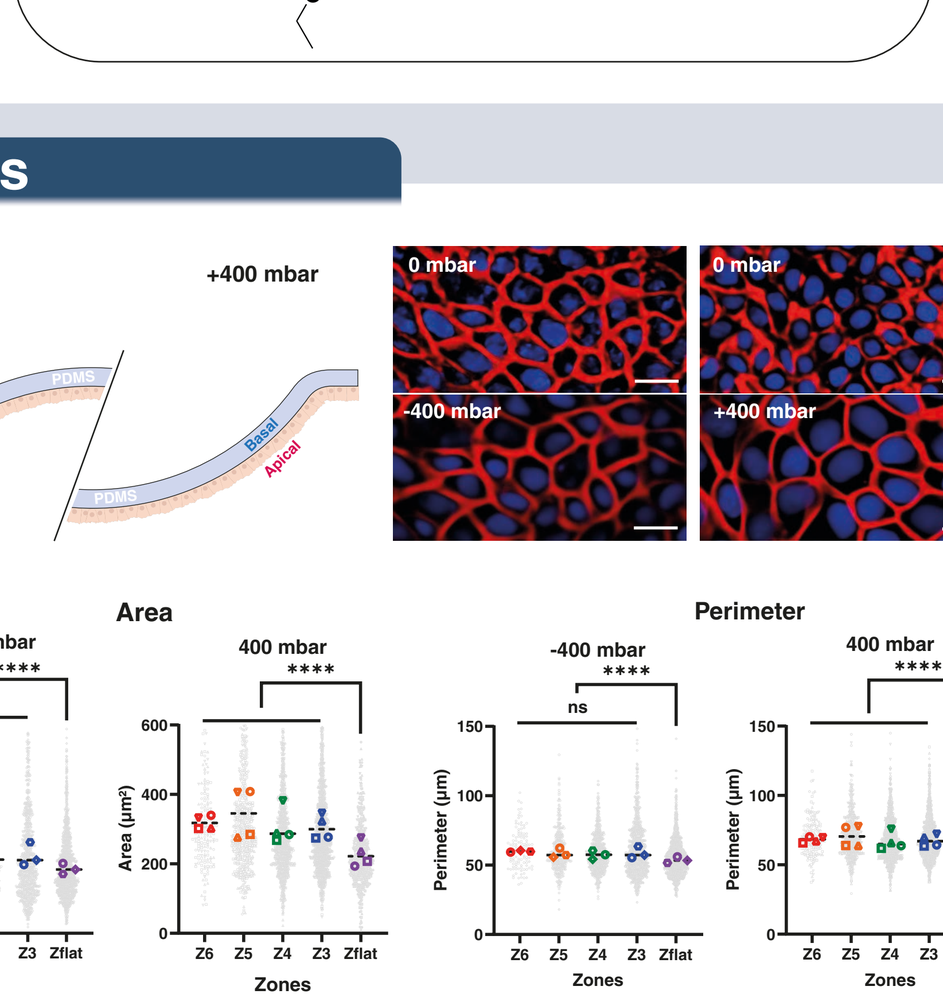
Introduction

Epithelial tissues cover a wide range of organs with intrinsically curved geometries, exhibiting curvatures ranging from 10^{-4} to 1 μm^{-1}. These tissues are continuously subjected to dynamic forces and deformations, leading to persistent curvature fluctuations. While extensive evidence highlights the influence of curvature on cell shape, orientation, migration, cytoskeletal organization, and collective behavior, the effects of dynamic curvature changes—and the extent and rate of cellular adaptations—remain poorly characterized.

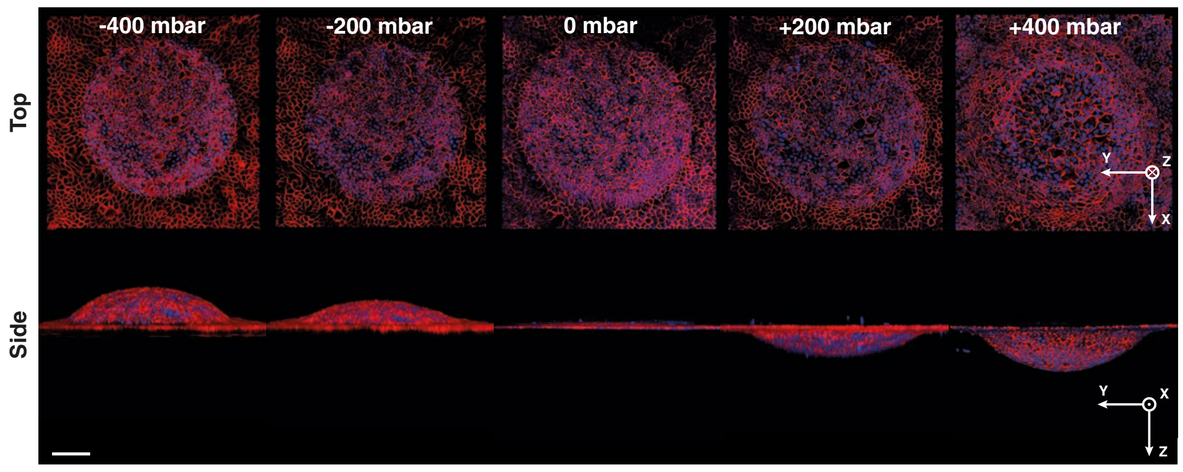
Concept

- **The system features a modular bottom part enabling two configurations: direct live observation under the microscope, or cell culture in an incubator.**
- **Positive pressure causes the PDMS to form hemispherical domes above the holes in the thermoplastic, while negative pressures create hemispherical cavities within the holes.**

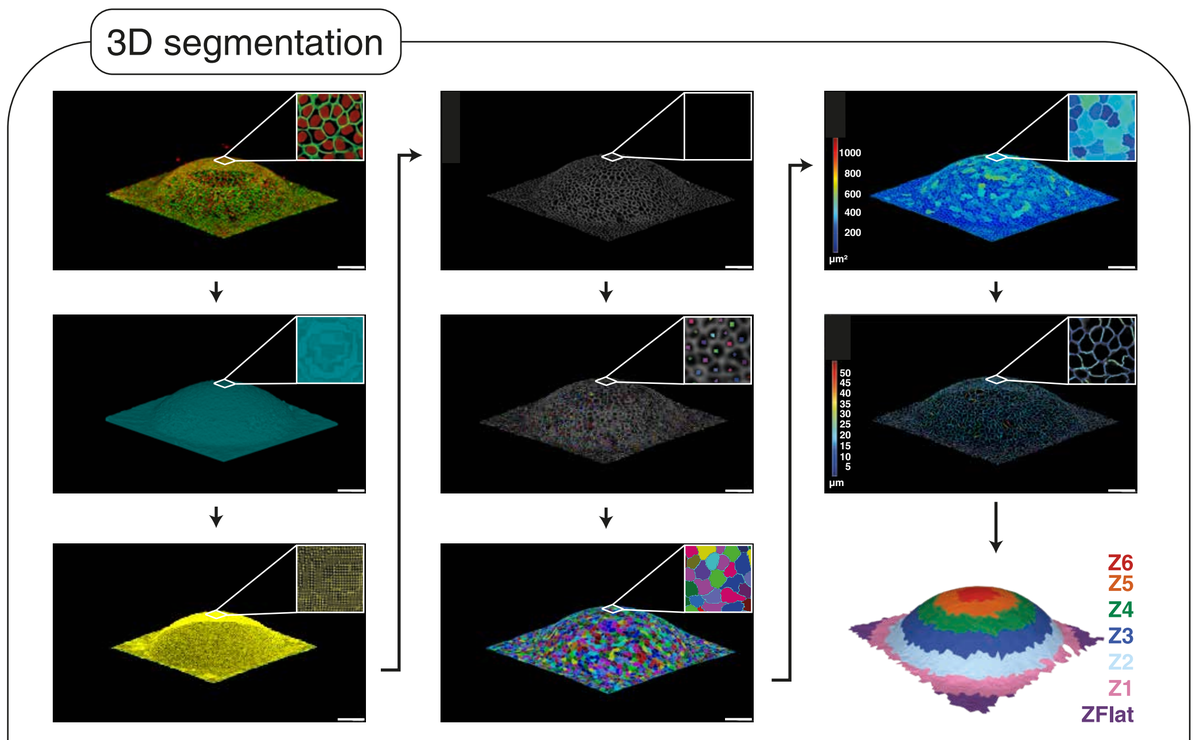




Analysis



Cell layer deformation in response to applied pressure. XY and YZ views of the deformed cell tissue above the thermoplastic holes under pressures ranging from -400 mbar to + 400 mbar. Scale bars : 100 µm



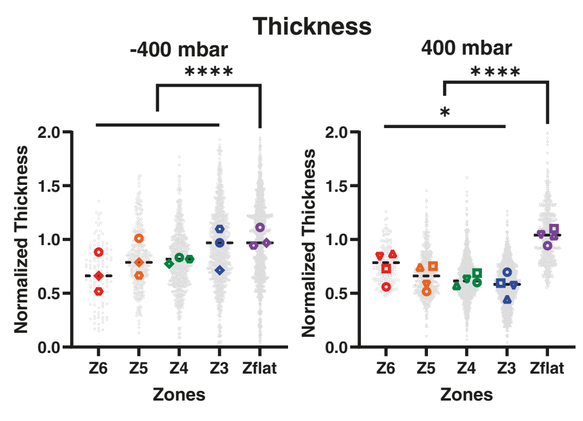
Analysis pipeline of the 3-dimensional curved shapes using **MorphographX**
The **fluorescence** imaging of the deformed tissue (nuclei in red; cell–cell junctions via E-cadherin in green). is used to extract the **shape** of the deformed tissue. The 3D surface is then **meshed** and the **cell-cell junctions signal** is projected on the 3D mesh. The cell positions are **seeded** and the cells are **segmented** using a Watershed algorithm. From this segmentation, the **cell areas** as the **cell-cell junctions** can be extracted and the deformed tissue can be **reconstructed**. Scale bars : 100 µm

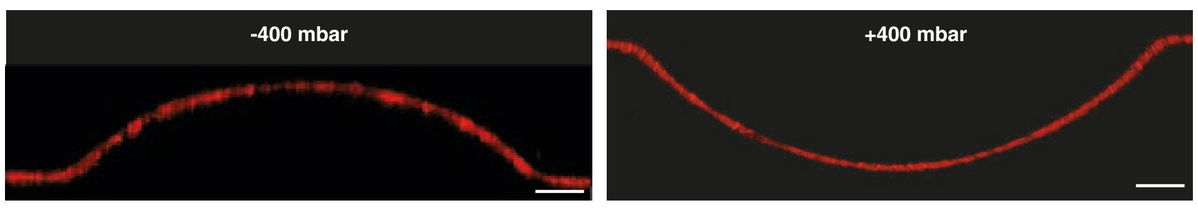
Results

Morphological evolution of a MDCK tissue under dynamic deformation

- An increase in both cell area and perimeter can be observed in response to curvature formation. However, noticeably higher morphological changes happen for the induced positive curvatures (dome-shaped)
- The thickness of the deformed tissue diminish compared to the flat tissue for both curvature signs, but with opposite variations from the basis of the dome/cavity to the apex

Scale bars : 50 µm





Acknowledgement : Rémi Tranzer is financially supported by FRIA-FNRS

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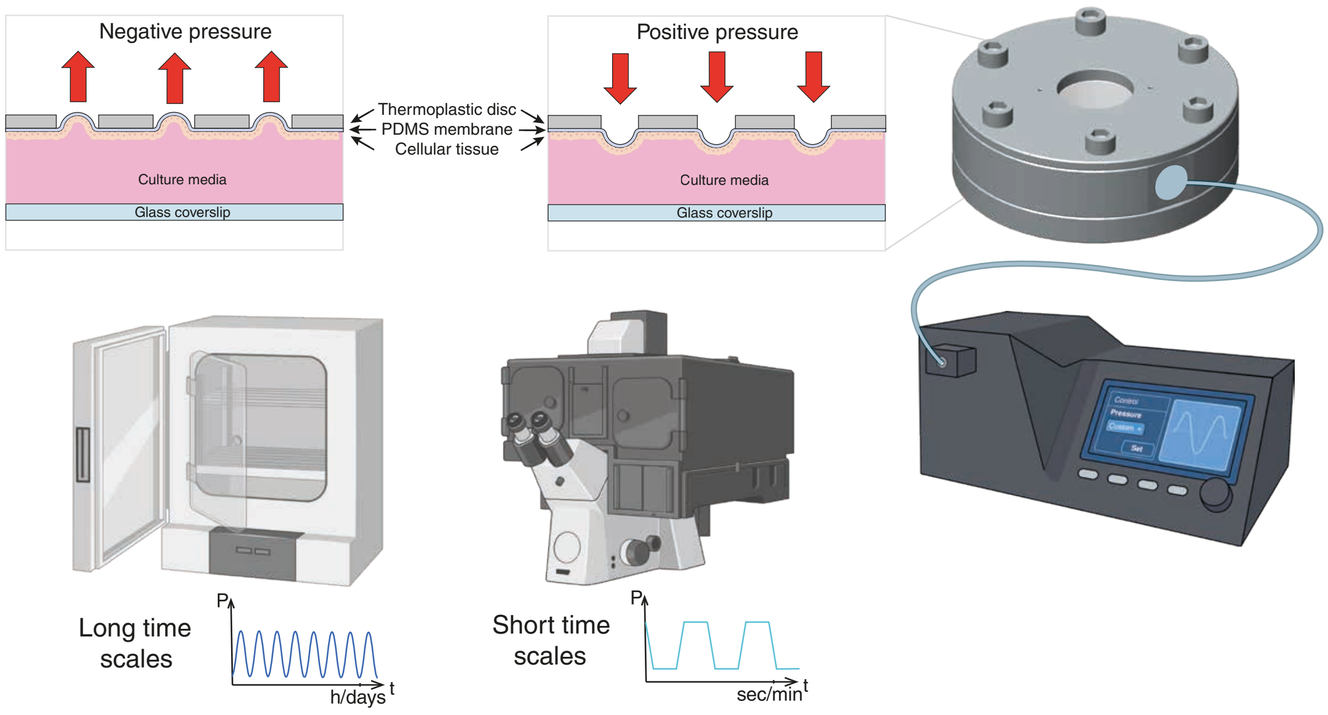

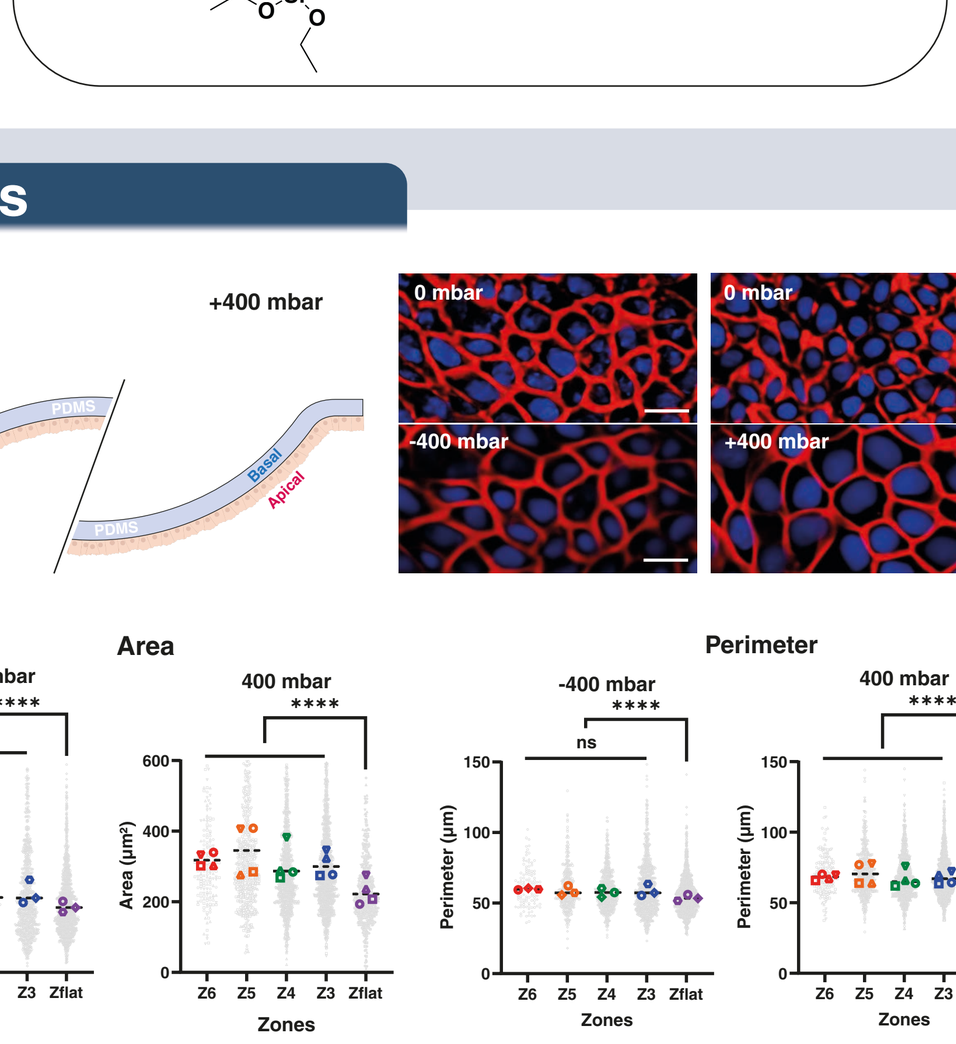

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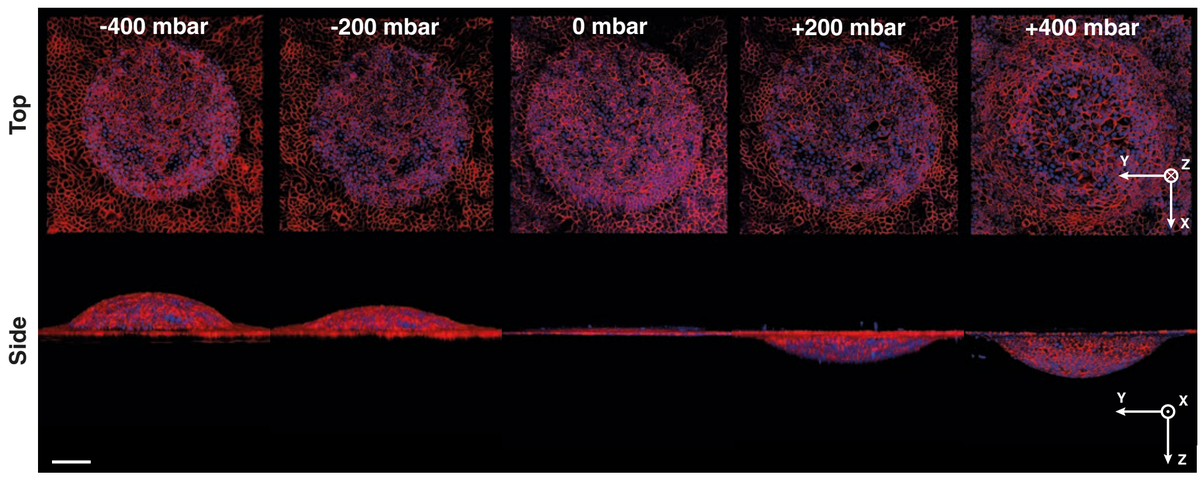

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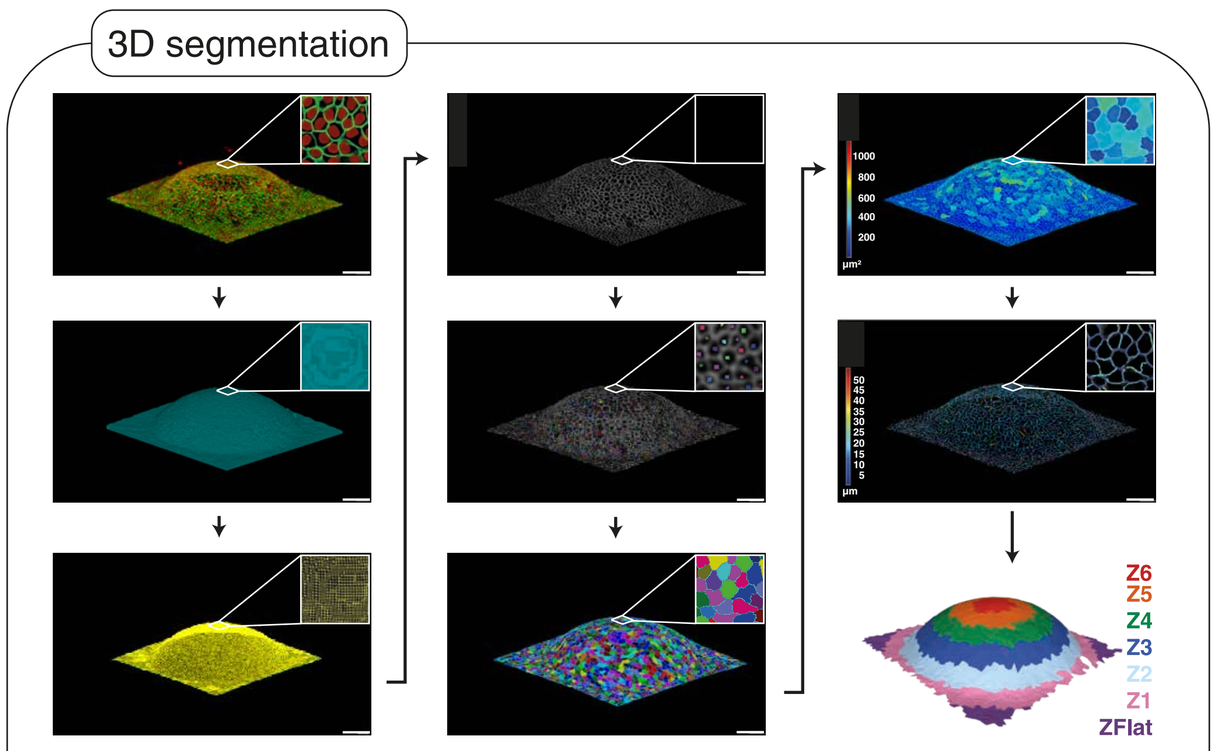

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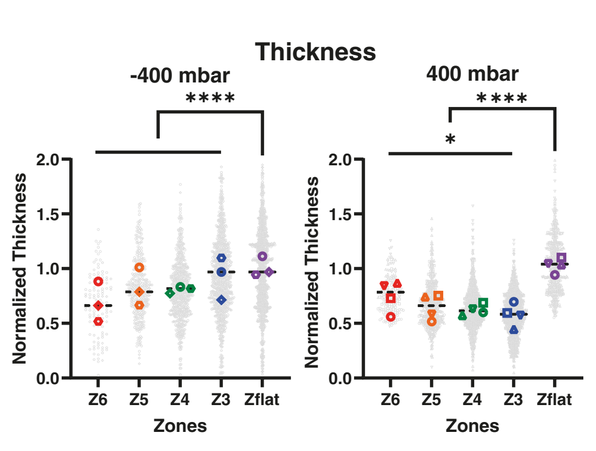

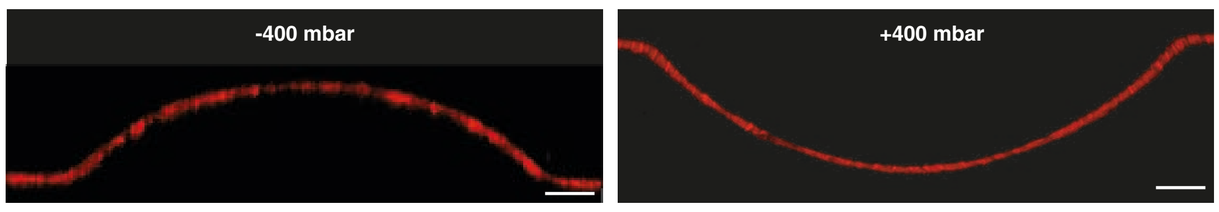

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