Robustness of tissue growth to cell mechanics

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Robustness of tissue growth to cell mechanics,
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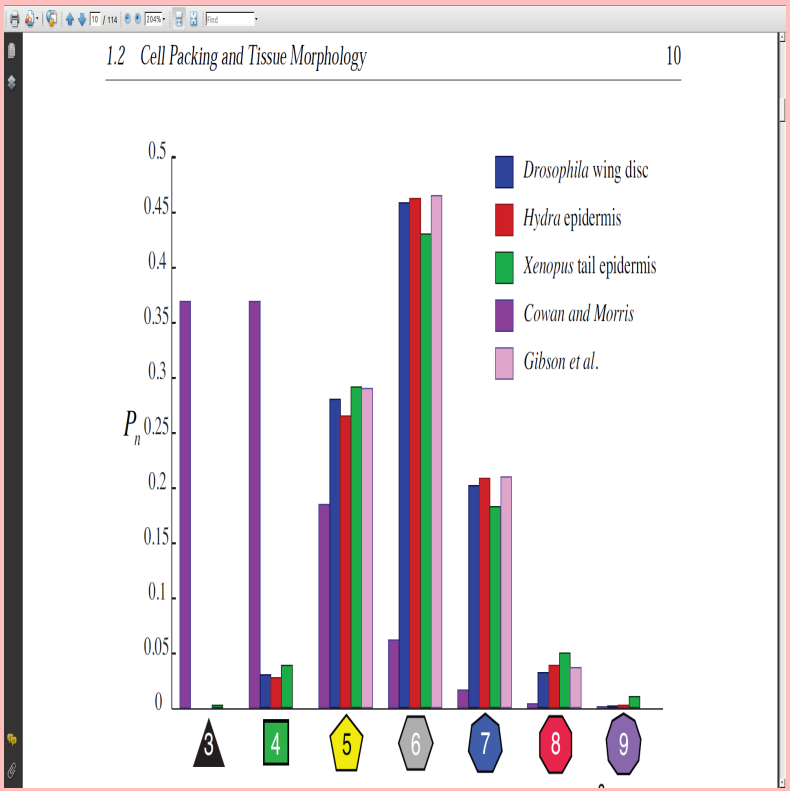
Tissue growth: cells as polygons, tissues as networks

Different kind of tissues



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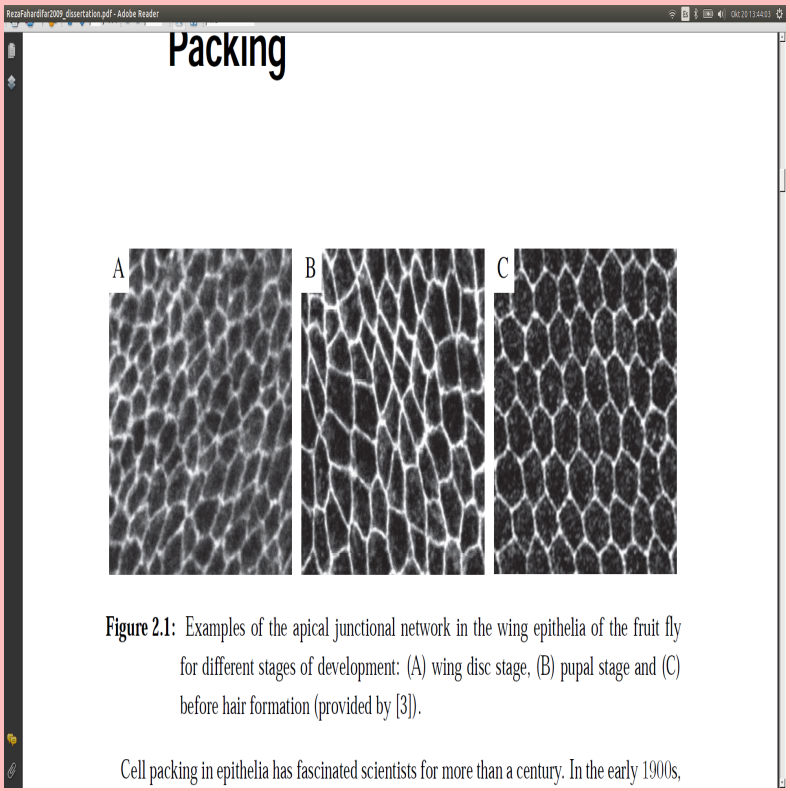
- Different cells *shapes* distributions are related to **different kind** of tissues[1].

Developmental stages of tissues



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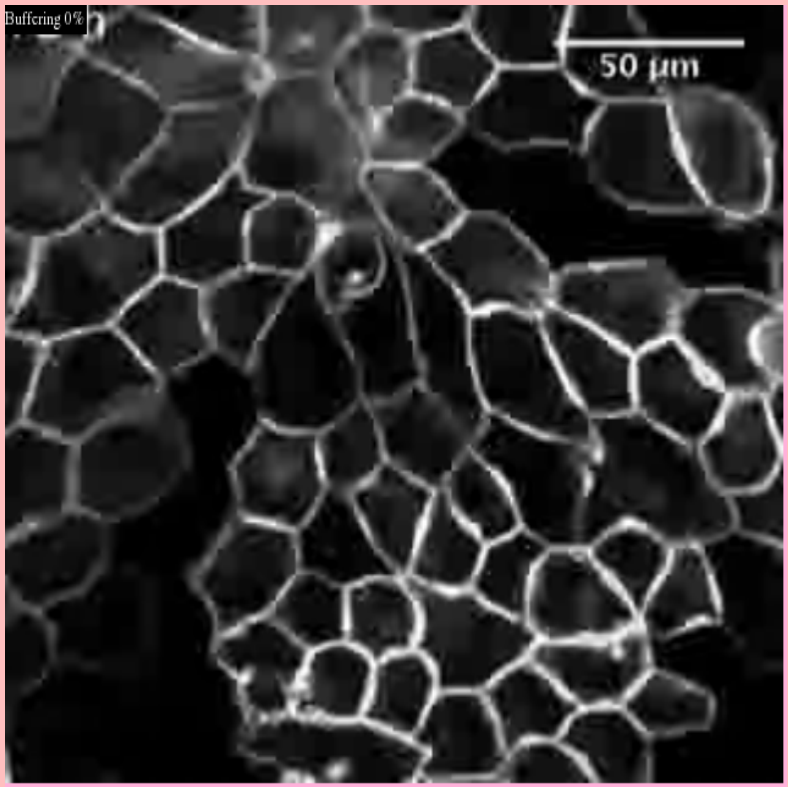
- Different cells *shapes* distributions are related to different **developmental stages** of a same tissue[2].

Tissue, cells, Edges, and Vertices



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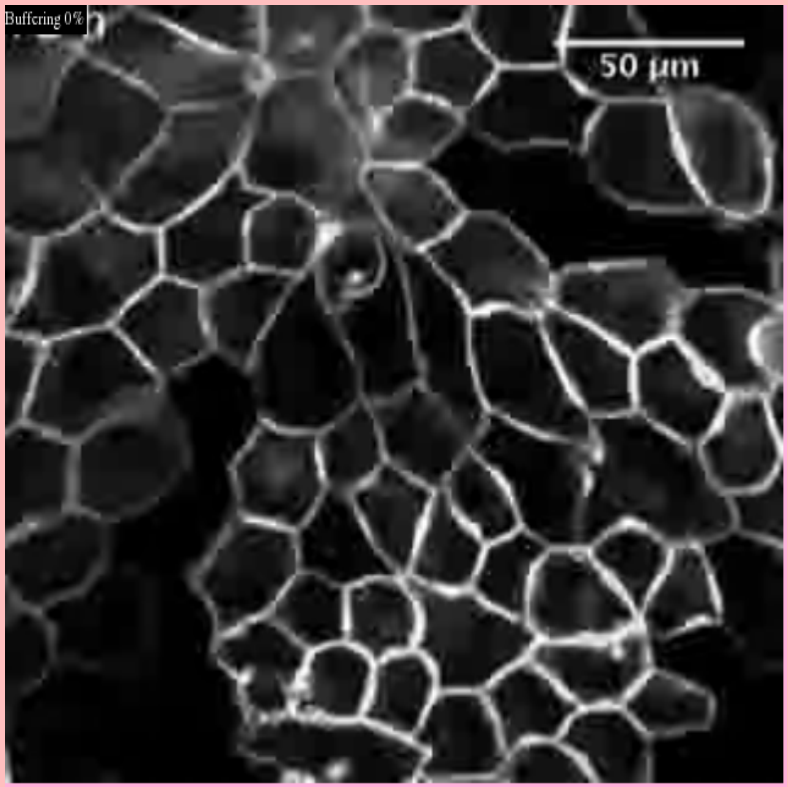
1. Tissue as a network of cells.

Tissue, cells, Edges, and Vertices



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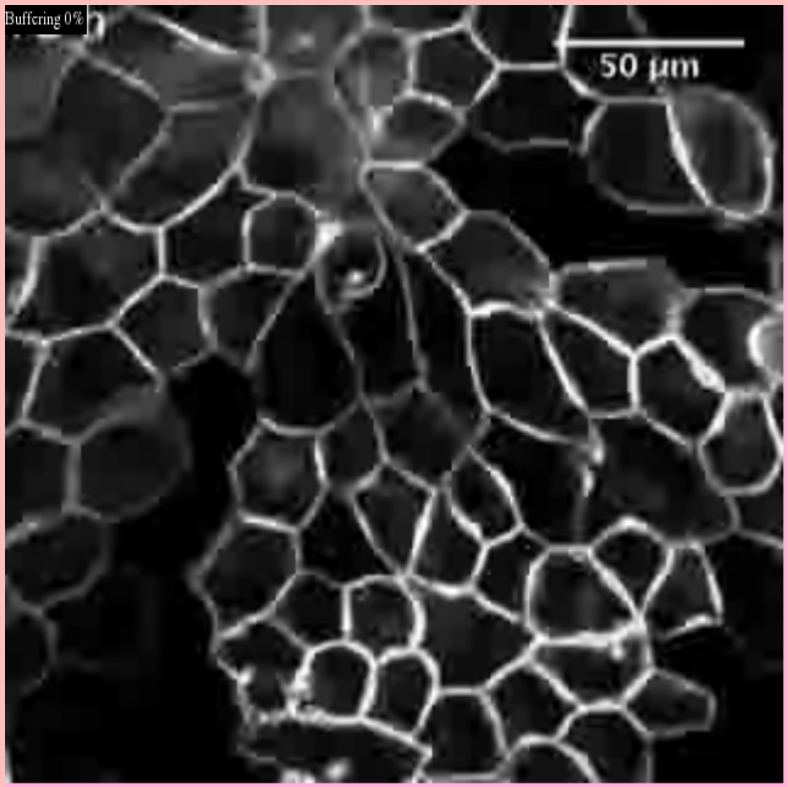
1. Tissue as a network of cells.
2. Cells as polygons.

Tissue, cells, Edges, and Vertices



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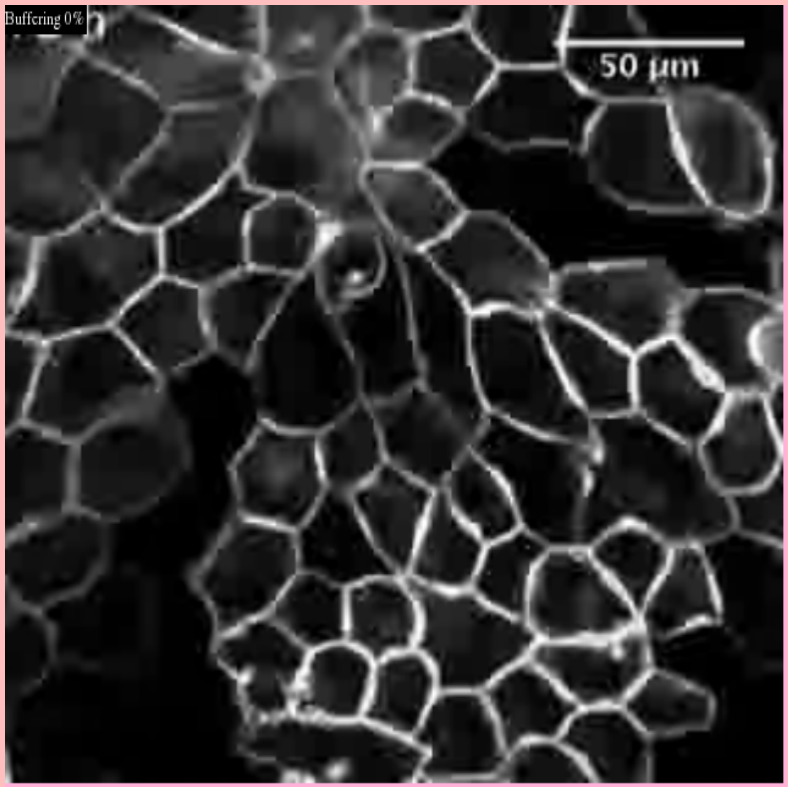
1. Tissue as a network of cells.
2. Cells as polygons.
3. Each 2 Cells share 1 Edge.

Tissue, cells, Edges, and Vertices



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1. Tissue as a network of cells.
2. Cells as polygons.
3. Each 2 Cells share 1 Edge.
4. Each Edge is composed by 2 Vertices.

Edge's Line Tension

Include figure of a cell from Farhadifar

- Edge's Line tension (Λ) is associated to Edge's length.

Cell's Contractility

Include figure of a cell from Farhadifar

- Cell's Contractility (Γ) is associated to Cell's Perimeter.

Cell's Elasticity

Include figure of a cell from Farhadifar

- Cell's Elasticity (K) is associated to Cell's Area.

Force Balance Energy Function

$$F = \sum_\alpha \frac{K_\alpha}{2}(A_\alpha - A_\alpha^{(0)})^2 + \sum_{(i,j)} \Lambda_{ij} L_{ij} + \sum_\alpha \frac{\Gamma_\alpha}{2} L_\alpha^2$$

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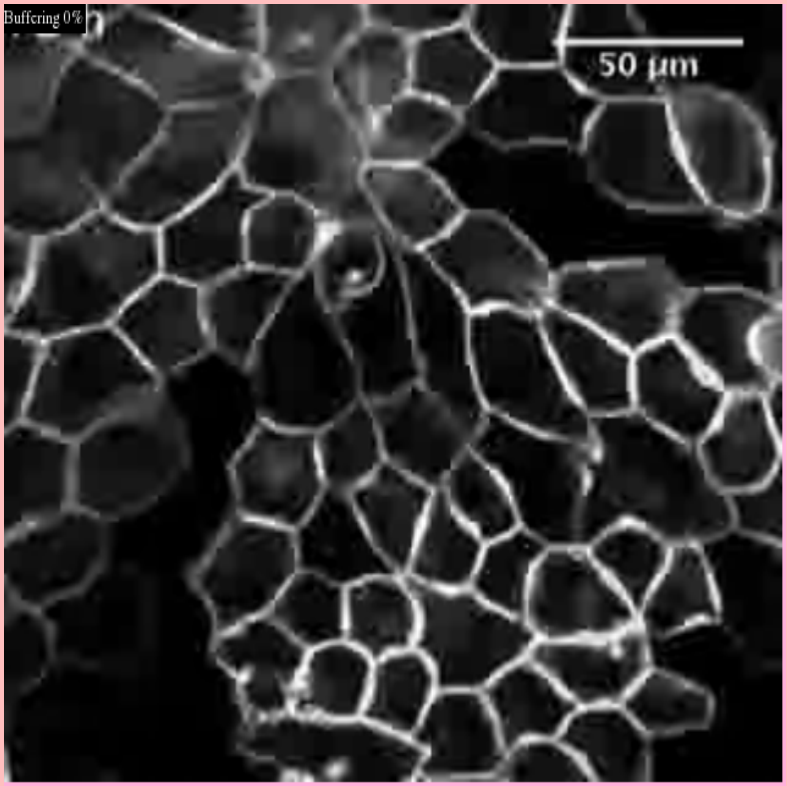
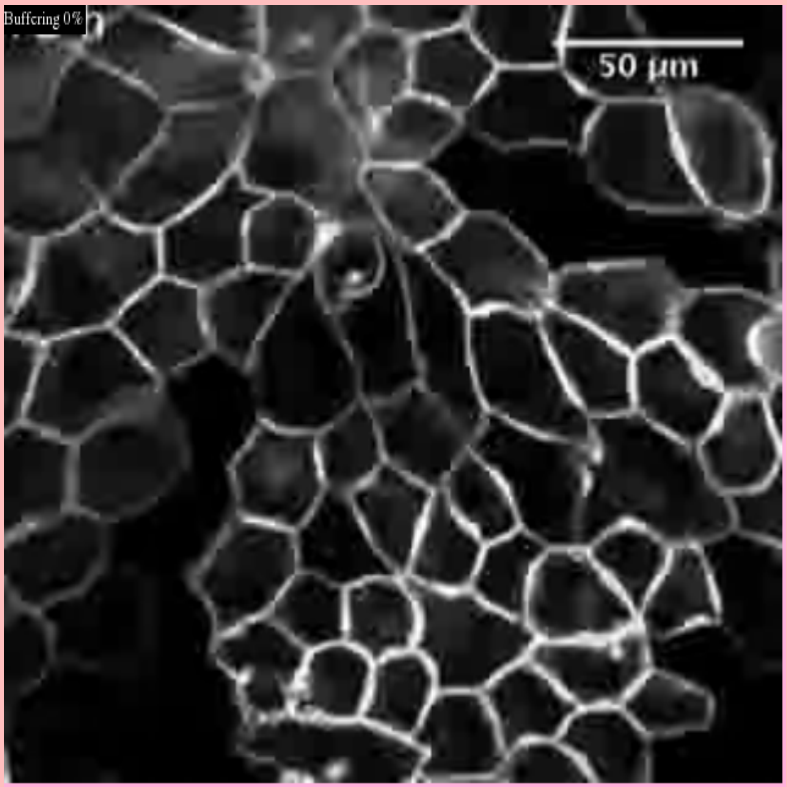


We keep the physical properties of the cells fixed during the simulation. So, in order to satisfy the **Minimal Energy's Assumption** theh positions of the vertices need to change.

Preferred Cell's Area $A_\alpha^{(0)}$

$$F = \sum_\alpha \frac{K_\alpha}{2}(A_\alpha - A_\alpha^{(0)})^2 \; + \; \sum_{(i,j)} \Lambda_{ij} L_{ij} \; + \; \sum_\alpha \frac{\Gamma_\alpha}{2} L_\alpha^2$$



$A_\alpha^{(0)}$ is the preferred area of cell α which is related to the volume, V_α and height, h_α of the cell: $A_\alpha^{(0)} = \frac{V_\alpha}{h_\alpha}$

Sequence of Events

1. **Relaxation** (Vertices change their position to guarantee the force balance equal to zero).

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1. **Relaxation** (Vertices change their position to guarantee the force balance equal to zero).
2. **Cell Proliferation** (cells growth and cells division).

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Relaxation

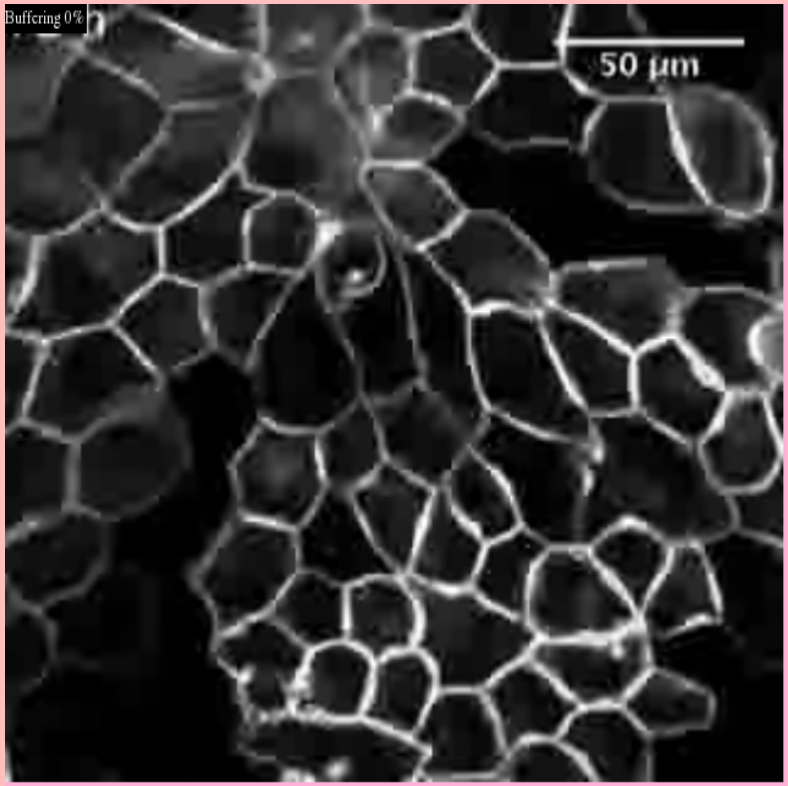
1. Vertices change their position to guarantee the force balance equal to zero.

Relaxation

1. Vertices change their position to guarantee the force balance equal to zero.
2. Relaxation is finished once the length of the tissue remains *steady* over 100 time steps ($\frac{sd(\sum_\alpha L_\alpha)}{\sum_\alpha L_\alpha} \approxeq 0$).

Regularness of the tissue

We define ***regularness*** as a dimensionless measure to say how regular the cells of a tissue are.



1. Regularne
as: $Reg =$
the edges.

Thank you!

- SystemsX Initiative.
- ***EpiphysX*** members: Andreas Wagner (UZH), Aziza Merzouki, Orestis Malaspinas, Bastien Chopard, Aurélien Roux, Michel Milinkovitch, Marcos Gonzalez-Gaitan (UNIGE)
- Chopard's Group members (UNIGE).
- Wagner's Group members (UZH).
- You, for the attention and patience.