

Master 2 ICFP - Physics of Multicellular Systems

Lesson 4

From cell to tissue tension

Hervé Turlier - February 13th 2023

Preliminaries

Recap of practical info

- Website with teaching material (slides, references, TDs)
<https://hturlier.github.io/M2ICFP/>
- **5 Lessons on tissue mechanics**
 - **Feb 13th - Lesson 4:** From cell to tissue tension
 - Feb 20th - Lesson 5: Cell-cell interaction & patterning (**V. Hakim**)
 - **Mar 6th - Lesson 6:** Discrete (vertex) models of tissues
 - **Mar 13th - Lesson 7:** Continuous models of tissues: active-gels
 - **Mar 20th - Lesson 8:** Tissue rheology and rigidity transitions
 - **Mar 27th - Lesson 9:** Tissue growth and homeostasis
- **For practicals**
 - TDs 4-6 related to the content of the lesson of the same day.
 - The 3 last ones (TDs 7-9): one project among 2 propositions; in groups of 2-3 students; evaluation by the restitution of project's results

Tissue tension

Steinberg's differential adhesion hypothesis (DAH)

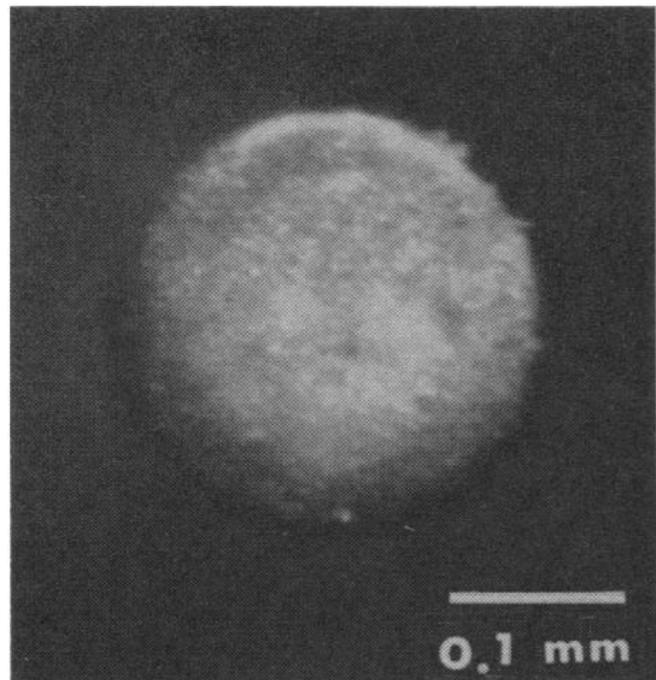
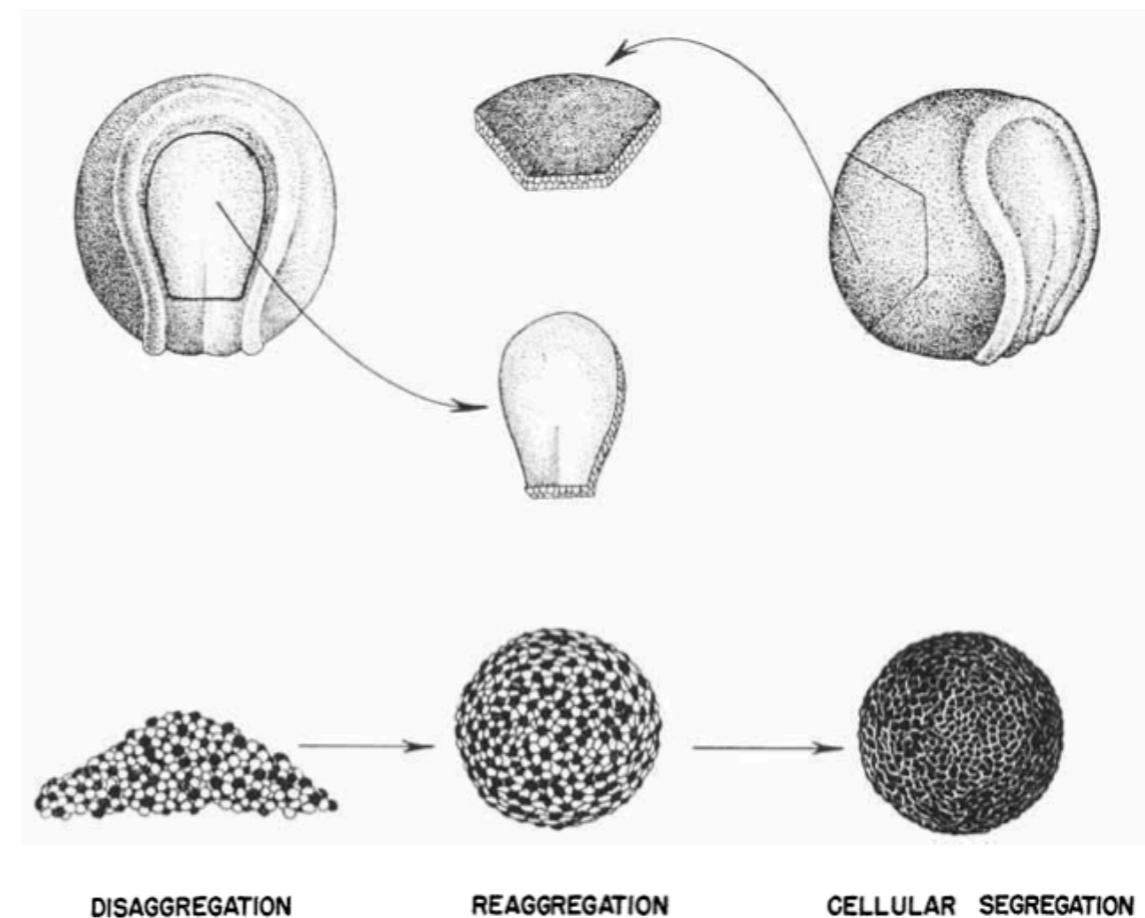


Fig. 1. An initially jagged fragment of liver that has assumed a spherical shape. Isolated from a 5-day chick embryo, it has been maintained in liquid medium at 37°C for 2 days under constant gyration. The same result is obtainable in a stationary culture.

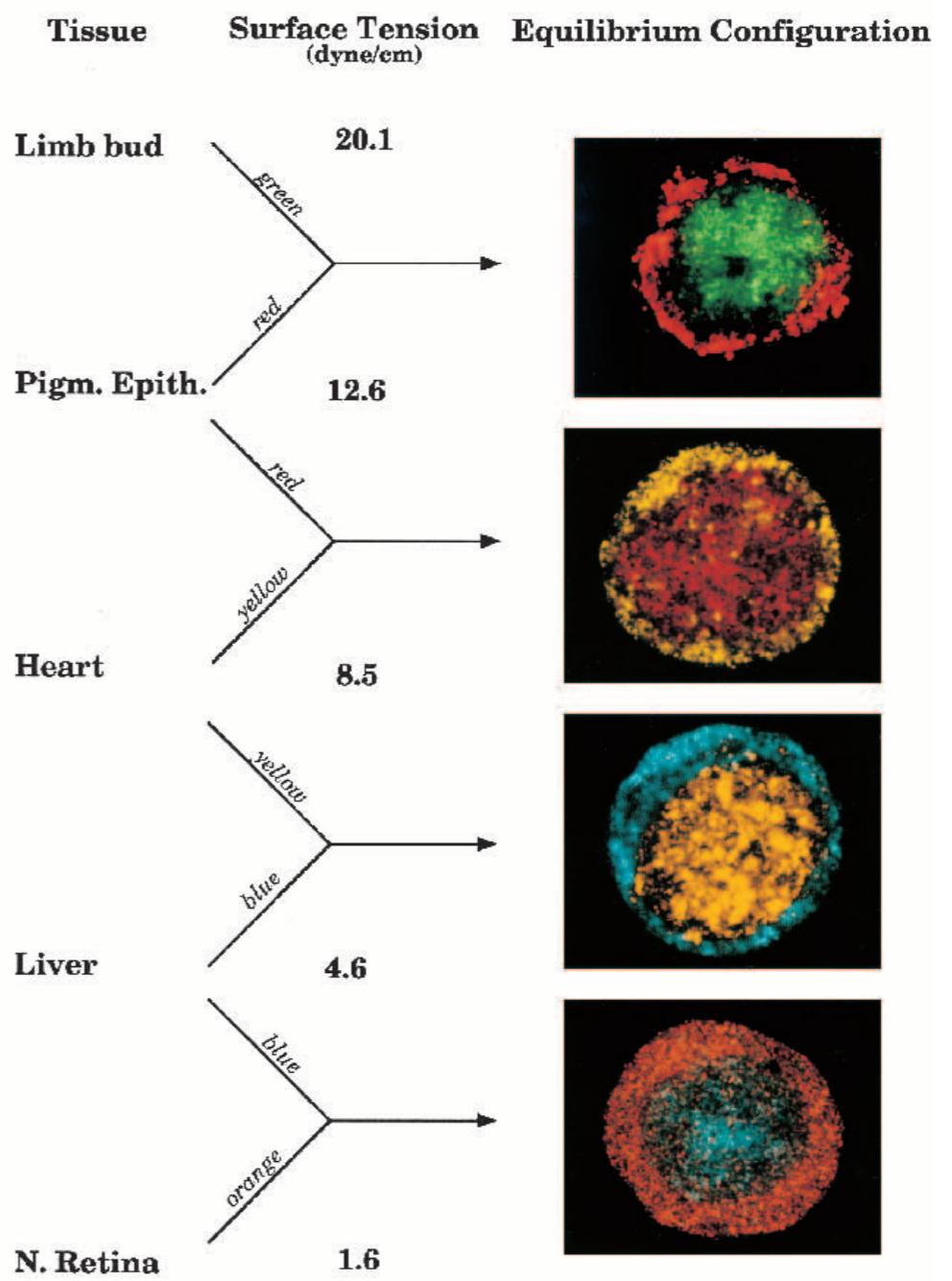
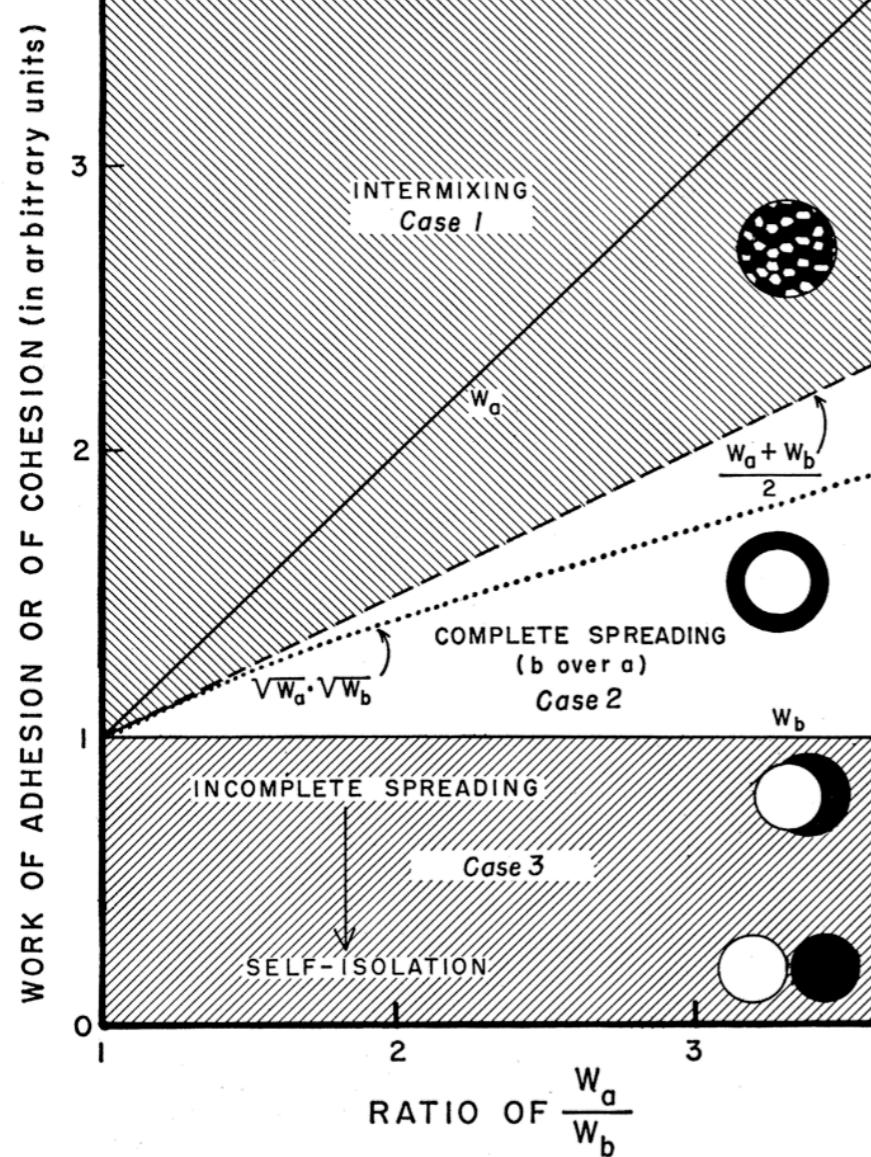


Steinberg *Science* 1963

Townes & Holtfreter *J Exp Zool* 1955

Tissue tension

Theory of sorting

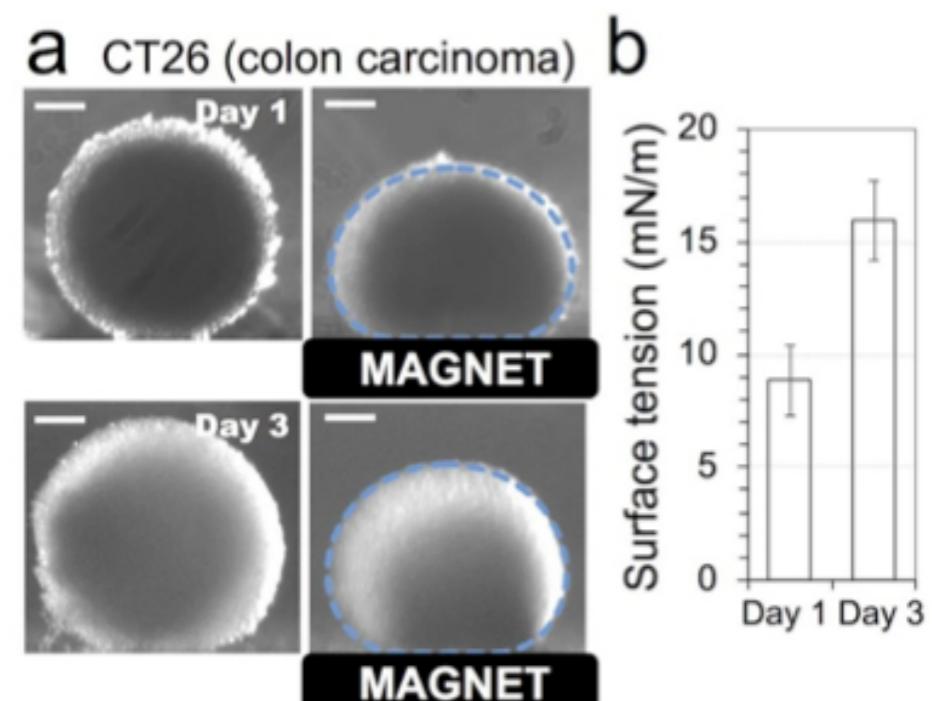
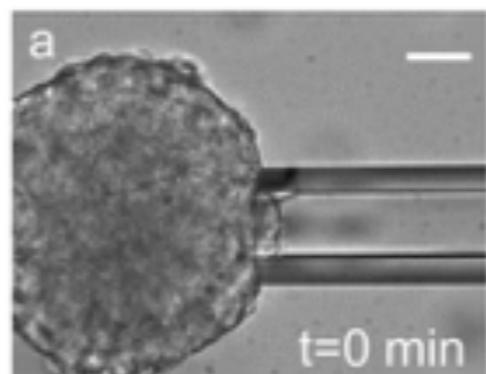
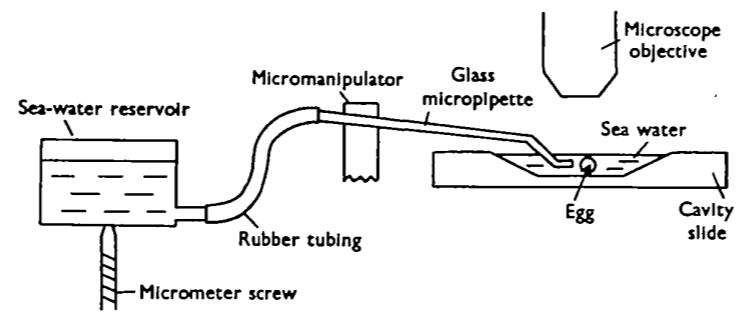
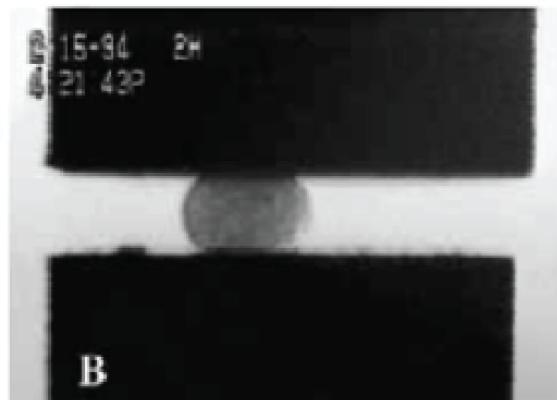
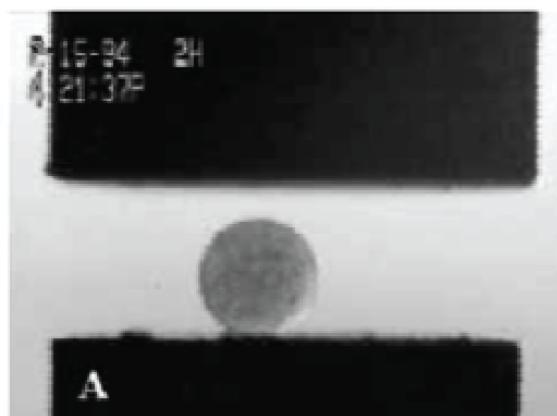


Steinberg Science 1963

Foty et al. Development 1996

Tissue tension

Measurement



Foty et al.
Physical Review Letters 1994

Norotte et al.
European Physics Letters 2008

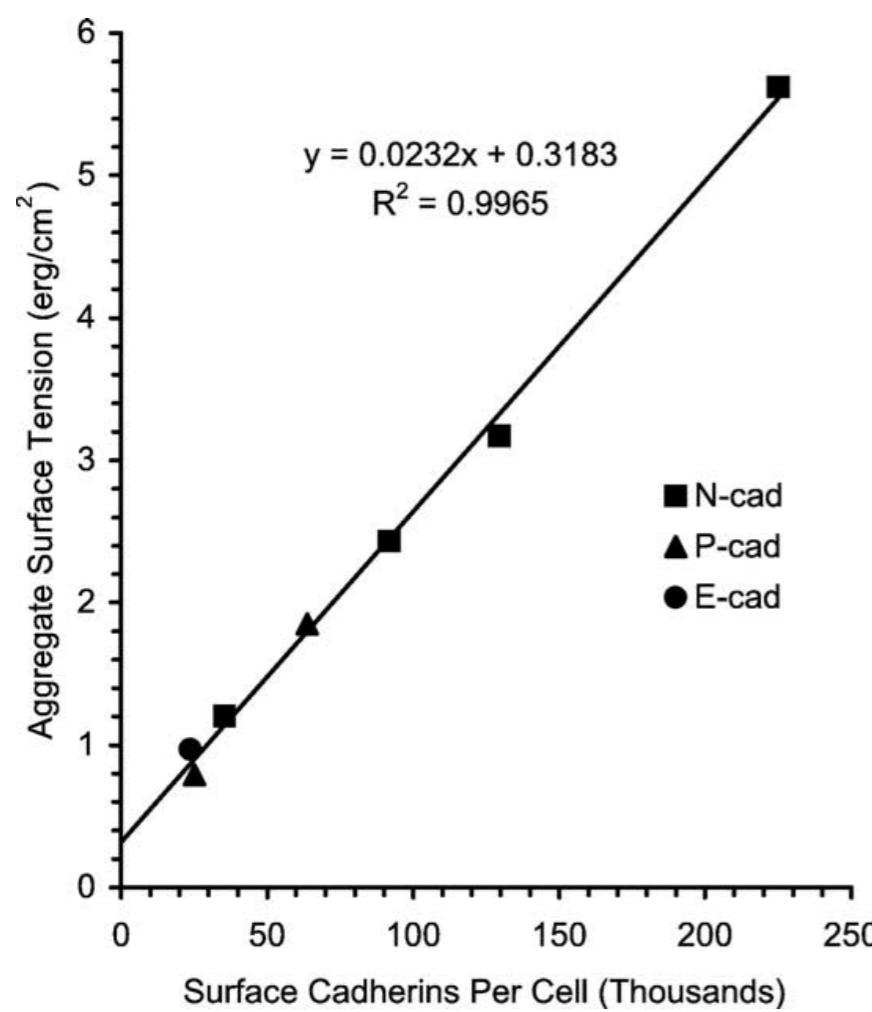
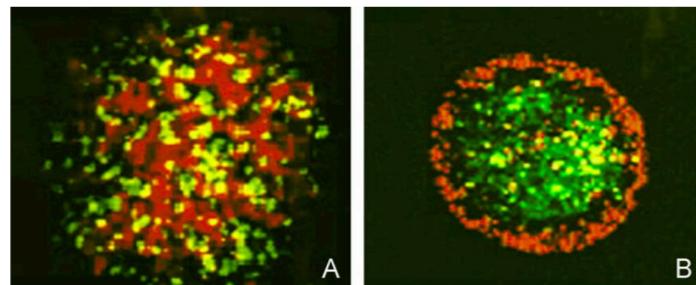
Mitchison et Swann.
J Exp Zoology 1954

Guevorkian et al.
Physical Review Letters 1994

Mazuel et al.
Physical Review Letters 2015

Tissue tension

Differential adhesion or tension hypothesis?



Foty et al. *Dev Biol* 2005

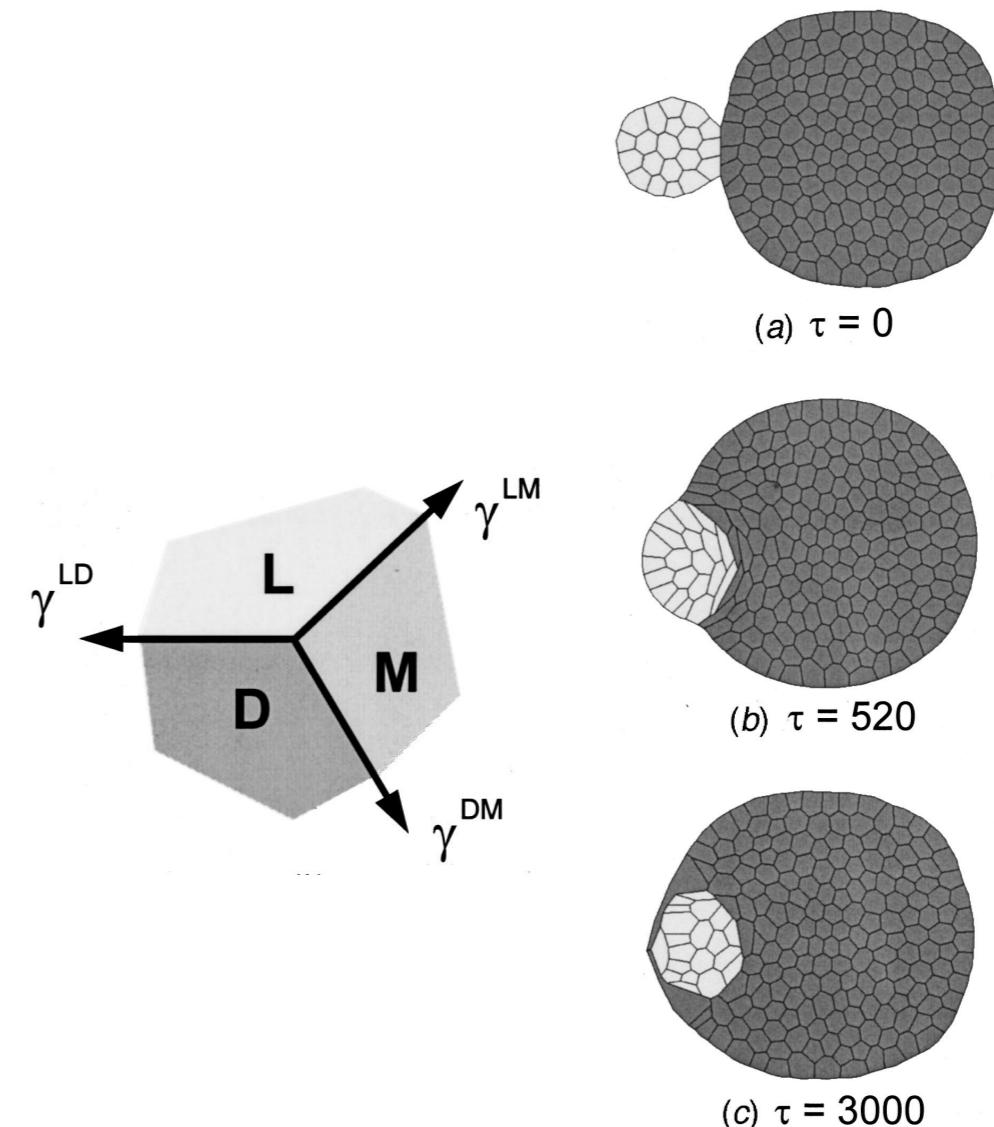


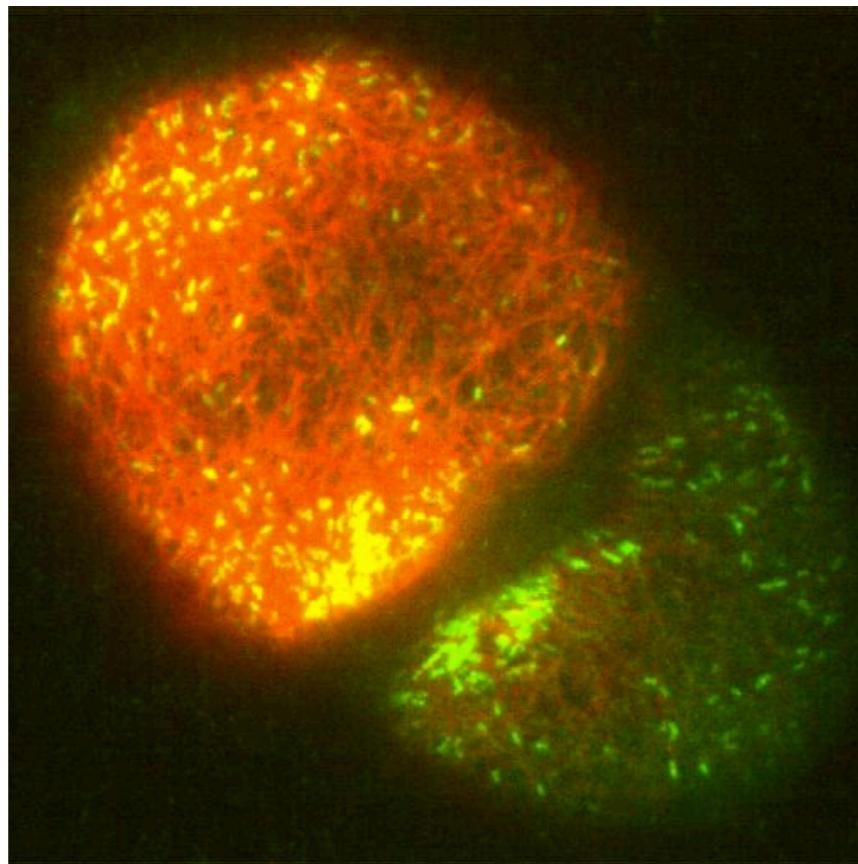
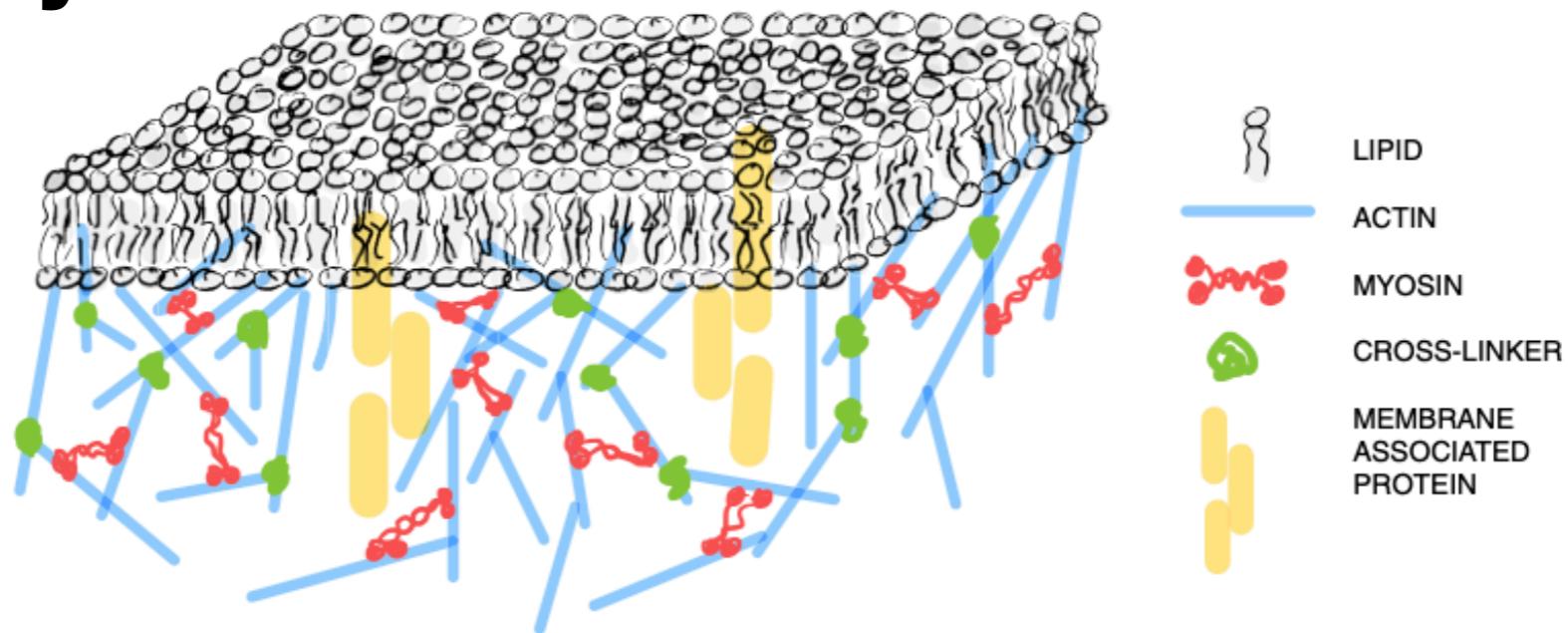
Fig. 8 Total engulfment of one type of tissue (L) by another (D) ($\gamma^{LL}=\gamma^{DD}=5$, $\gamma^{LD}=25$, $\gamma^{LM}=150$, $\gamma^{DM}=70$)

Harris. *J Theo Biol* 1996

Brodland. *J Biomech Eng* 2002

Cortical tension

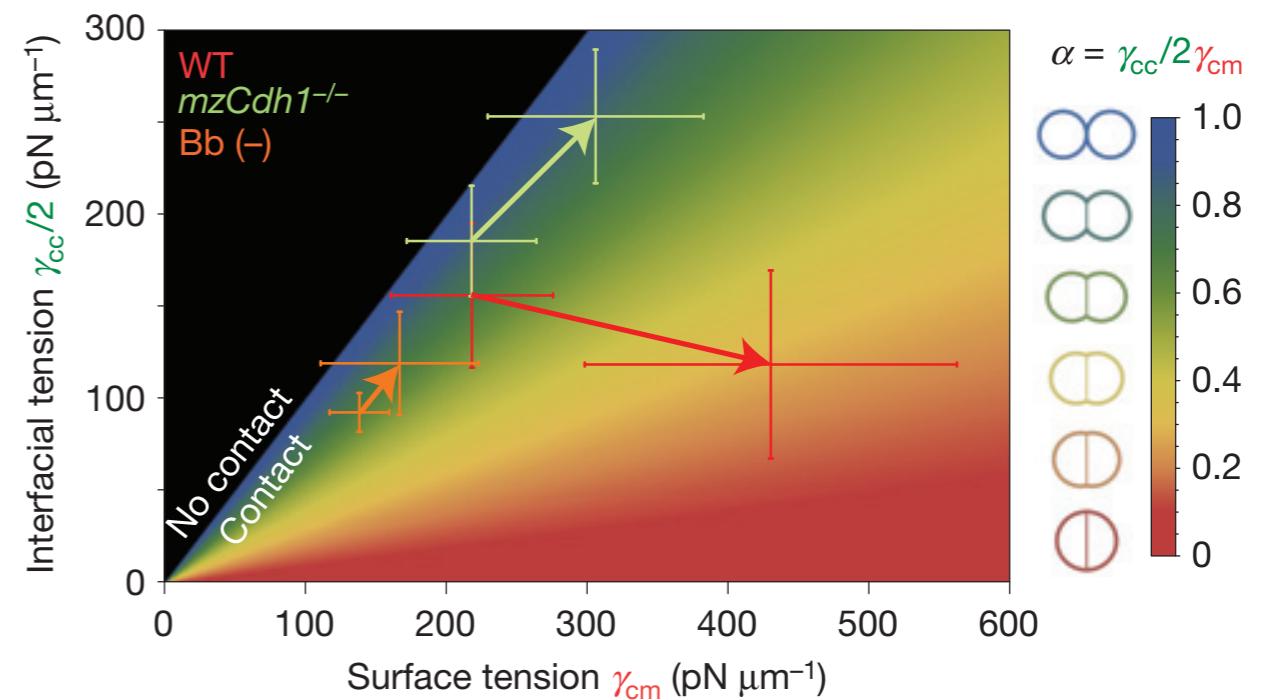
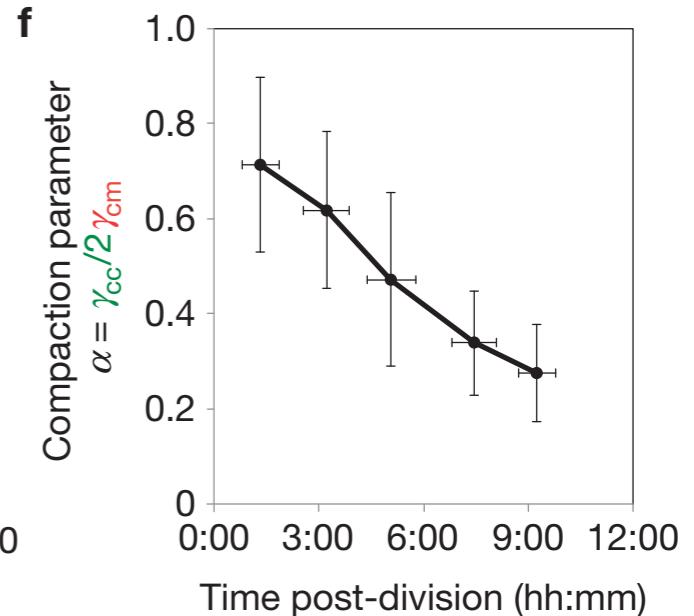
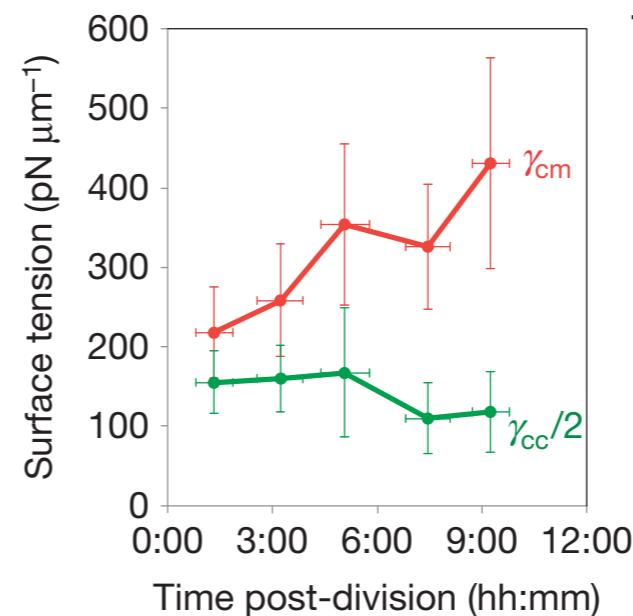
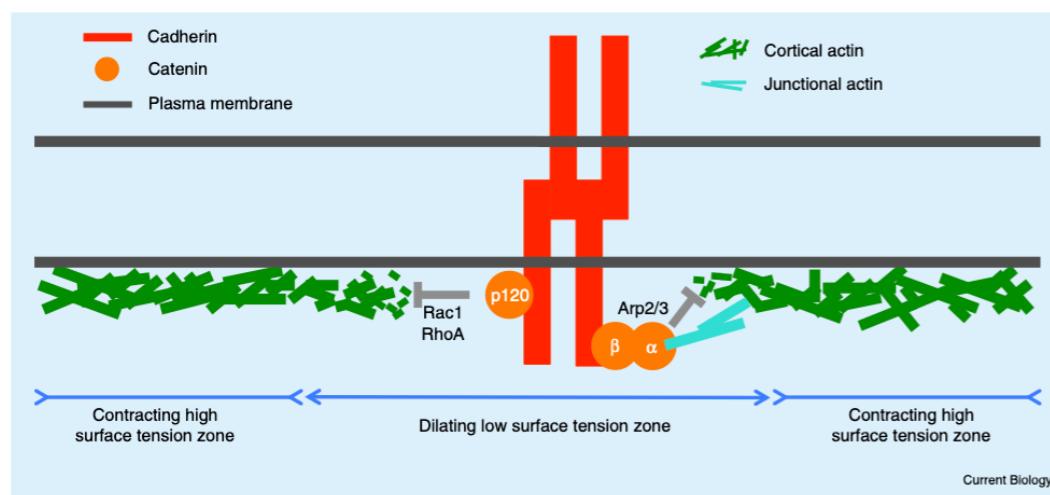
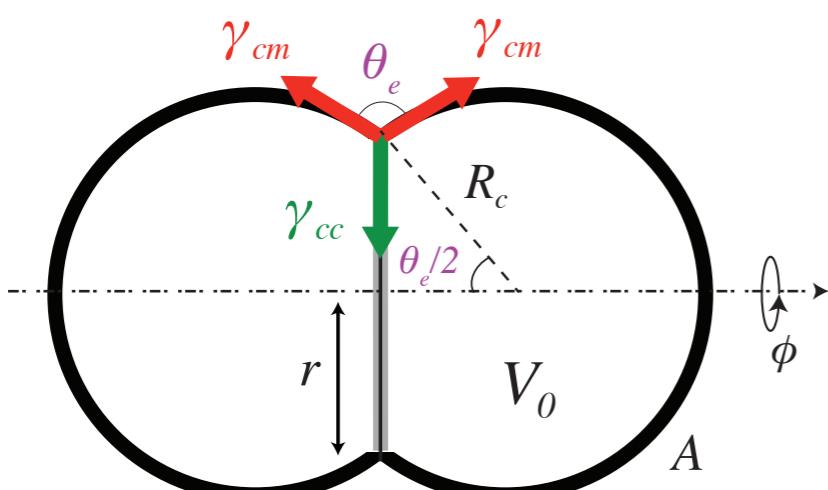
Contractility



F. Robin lab, Sorbonne U

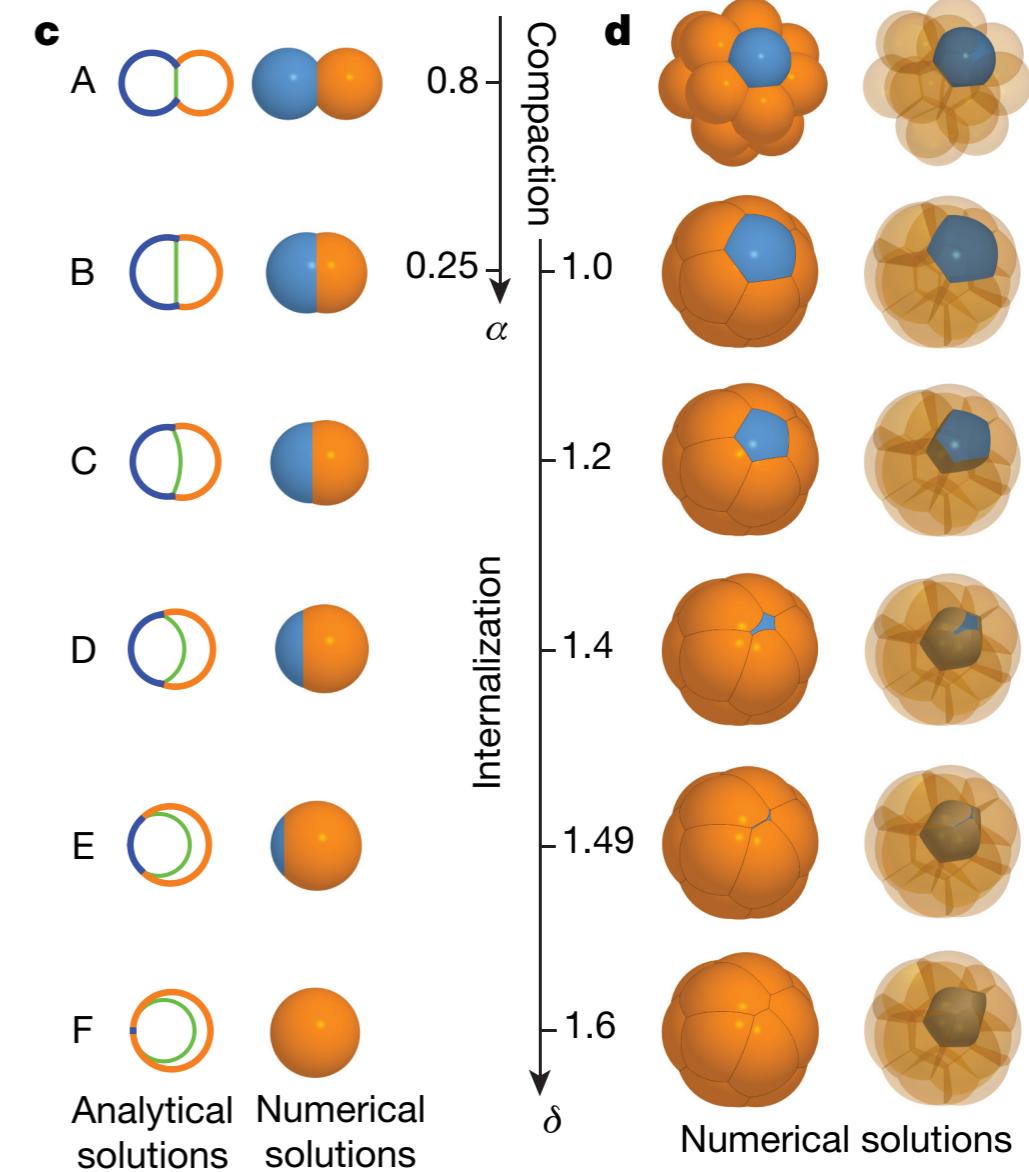
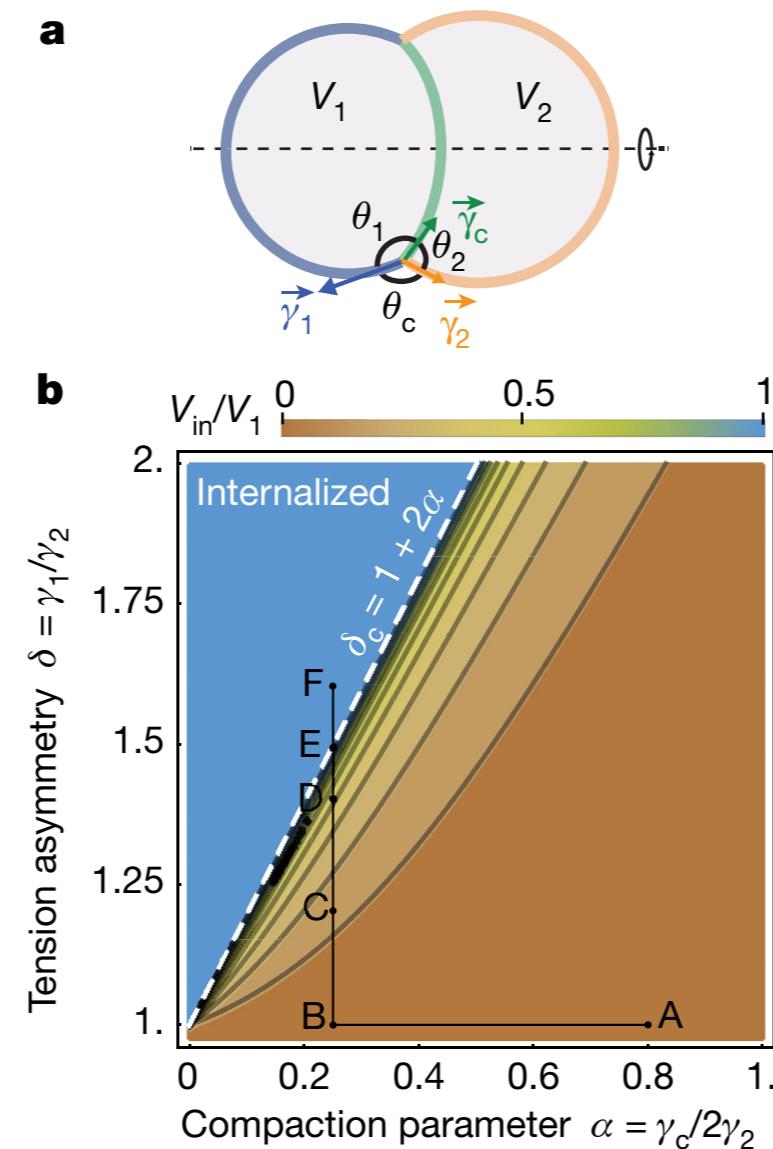
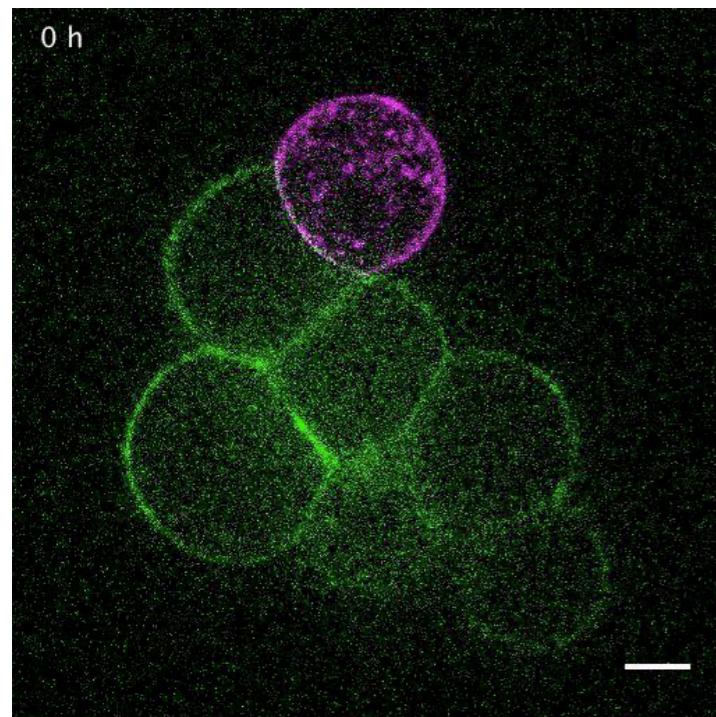
Cortical tension

Compaction and adhesion coupling



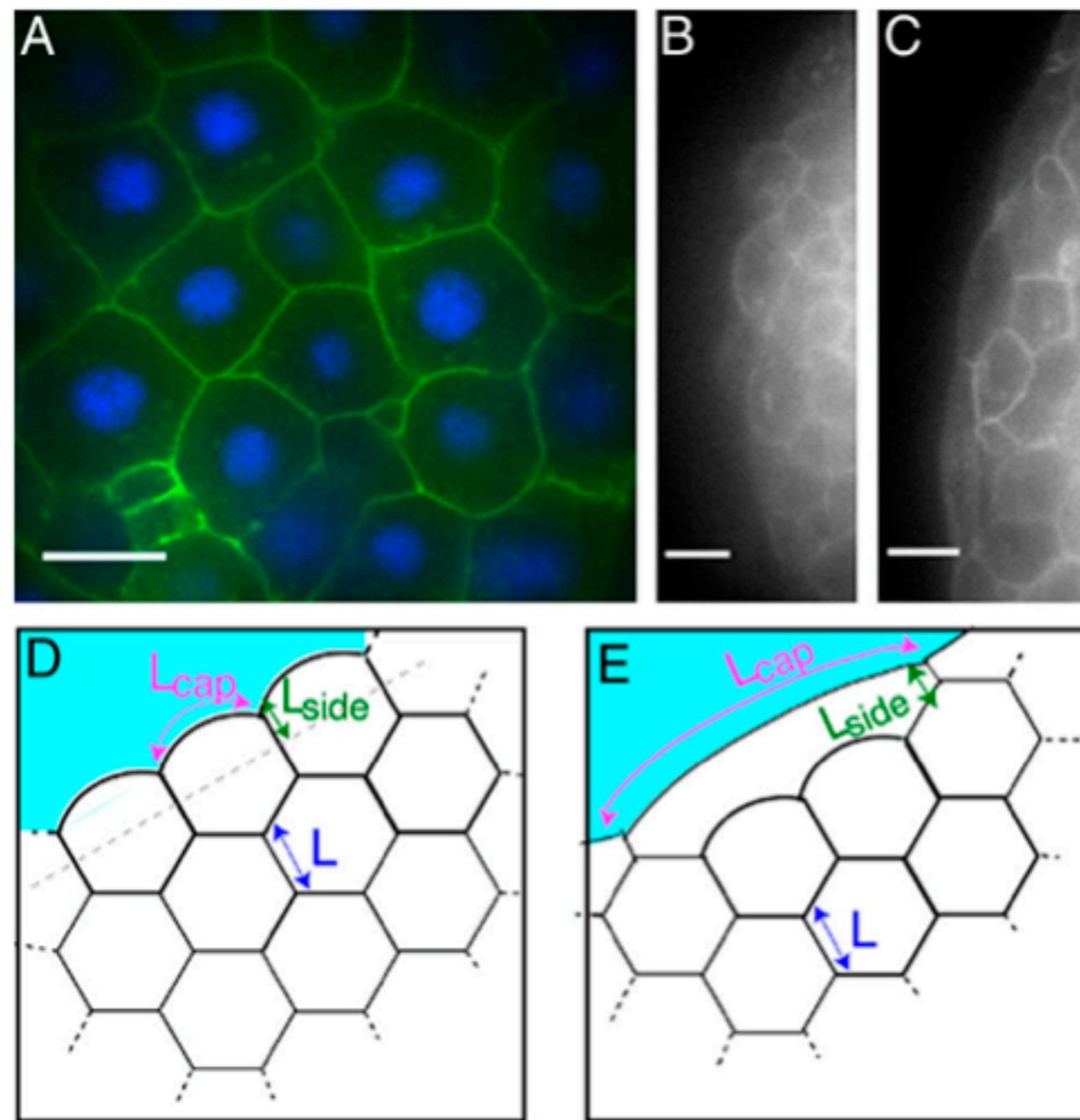
Cortical tension

Cell sorting (single cell engulfment)



Tissue tension

Lisa Manning's 2D model



Manning et al. PNAS 2010

Tissue tension

Lisa Manning's 2D model

