Biomimicking systems of cell shape changes

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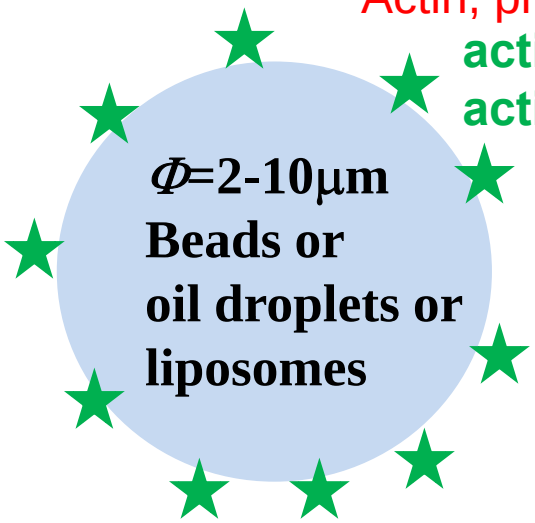
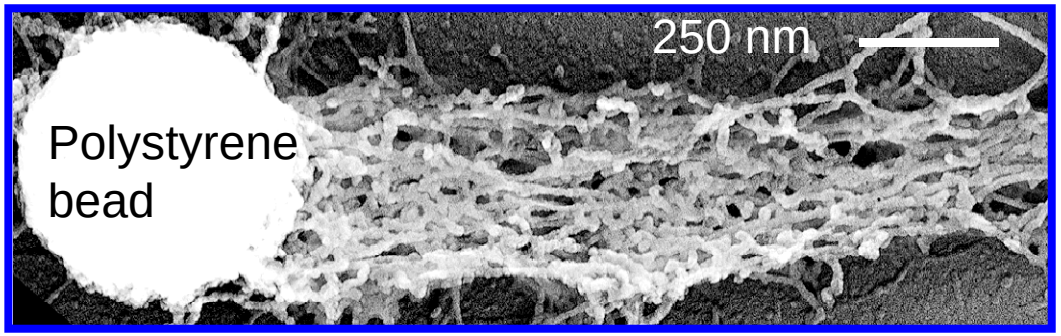


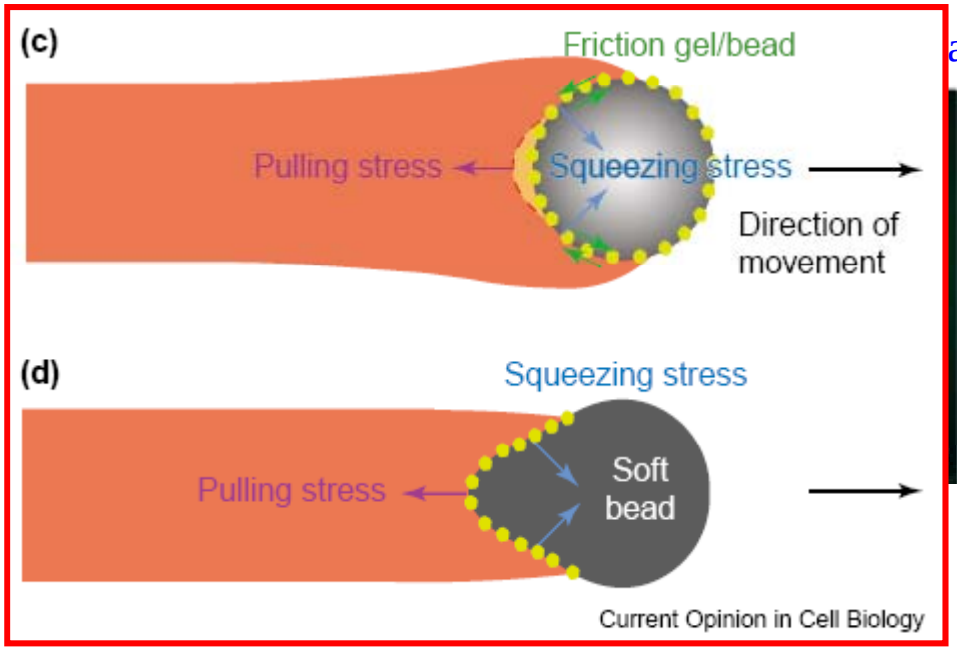
Actin, proteins (or cell extracts)

activator of the Arp2/3 complex,

actin polymerisation

Lamellipodia like comets

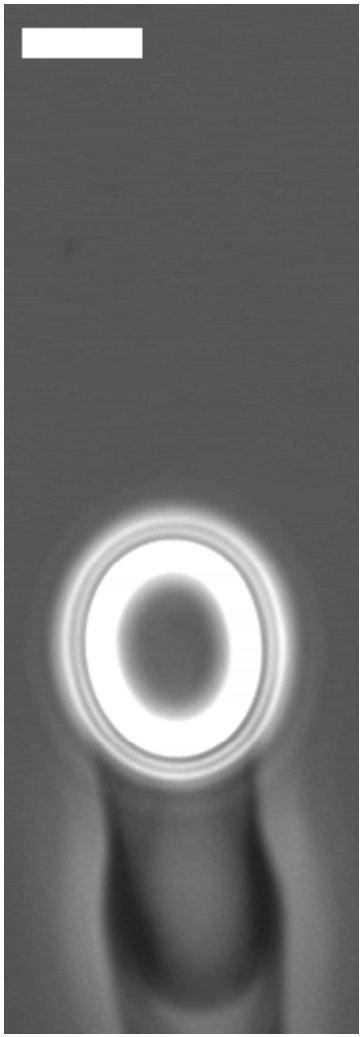




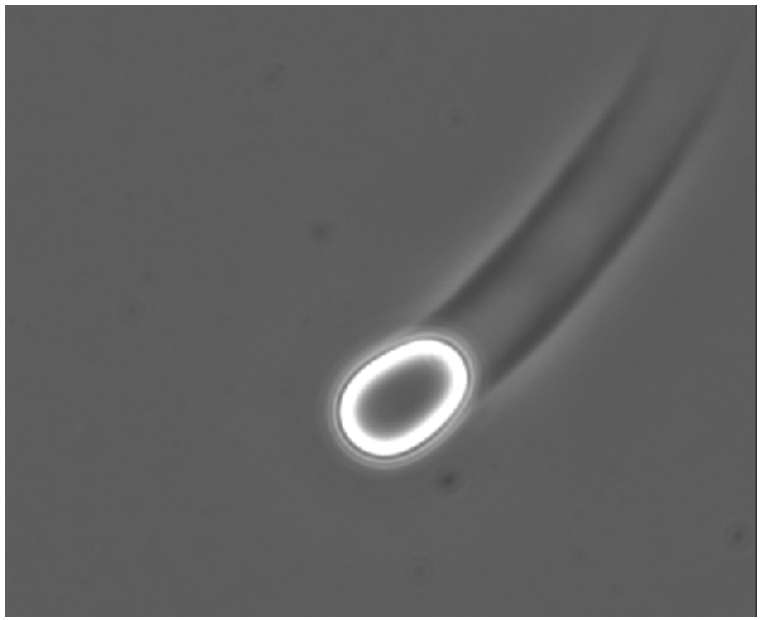
astino, S. Olivier, C. Sykes, *Current Biology* 2004]

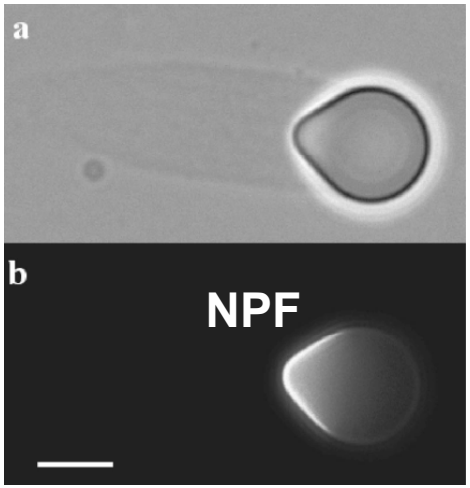
[E. Paluch, J. van der Gucht, *BJ* 2006]

Φ=4μm



Φ=7μm



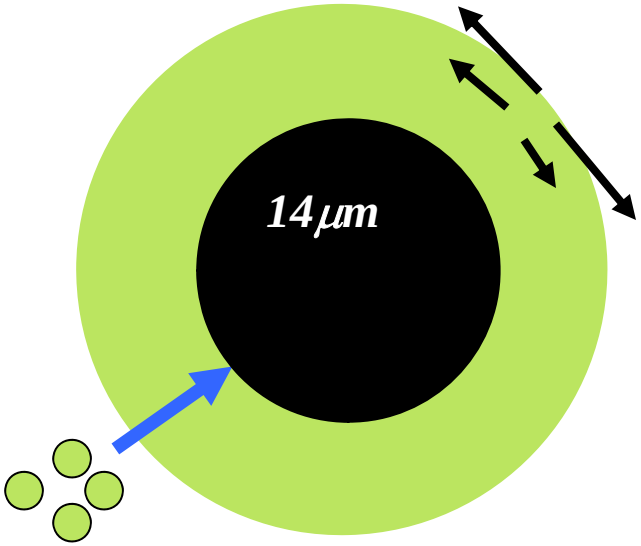


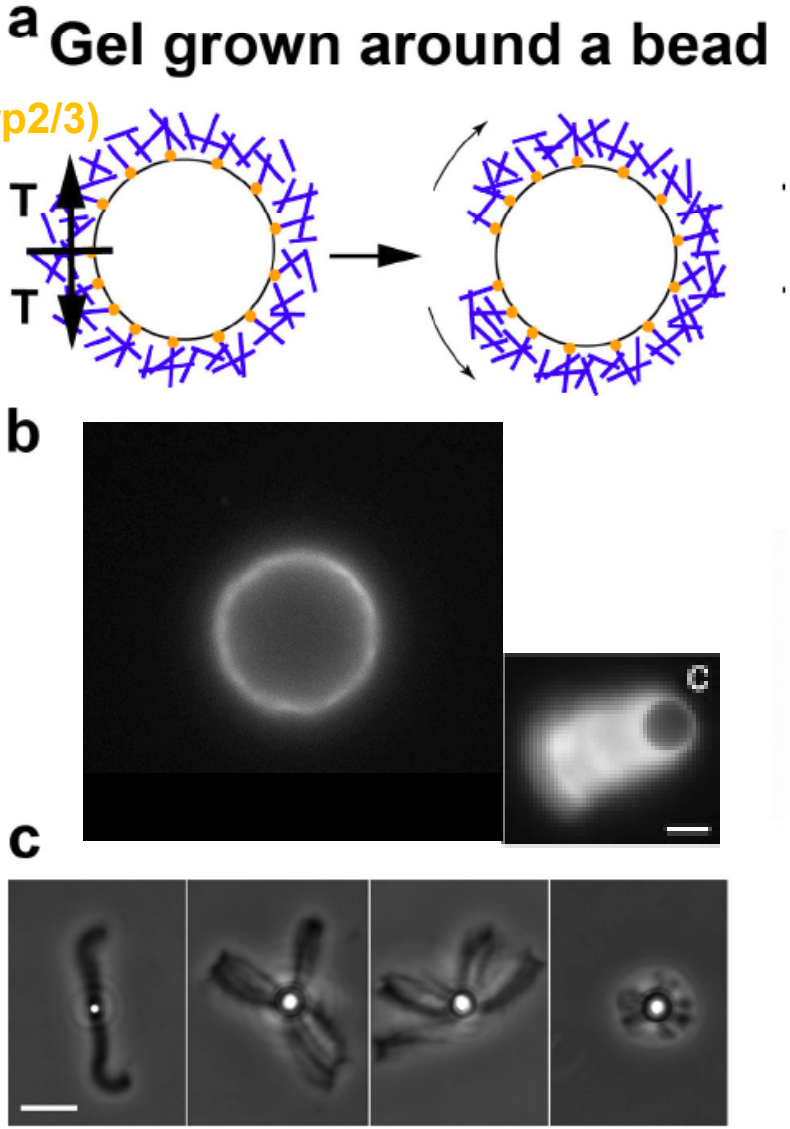
[H. Boukellal, 2004]

+VASP that detaches the NPF from actin

[L. Trichet, *BJ* 2007]

Gel growth-symmetry breaking-movement





low gelsolin concentration

[J. Plastino, Curr Op in Cell Biol 2005]

[J. van der Gucht PNAS 2005, E. Paluch, *JCB* 2006]

- **Formation of actin shells around beads for stress buildup**

- **Artificial corteces in liposomes (inside-out geometry of actin shells)**

- **Mechanical characterisation of artificial corteces (tube pulling)**

- **Formation of actin shells around beads for stress buildup**

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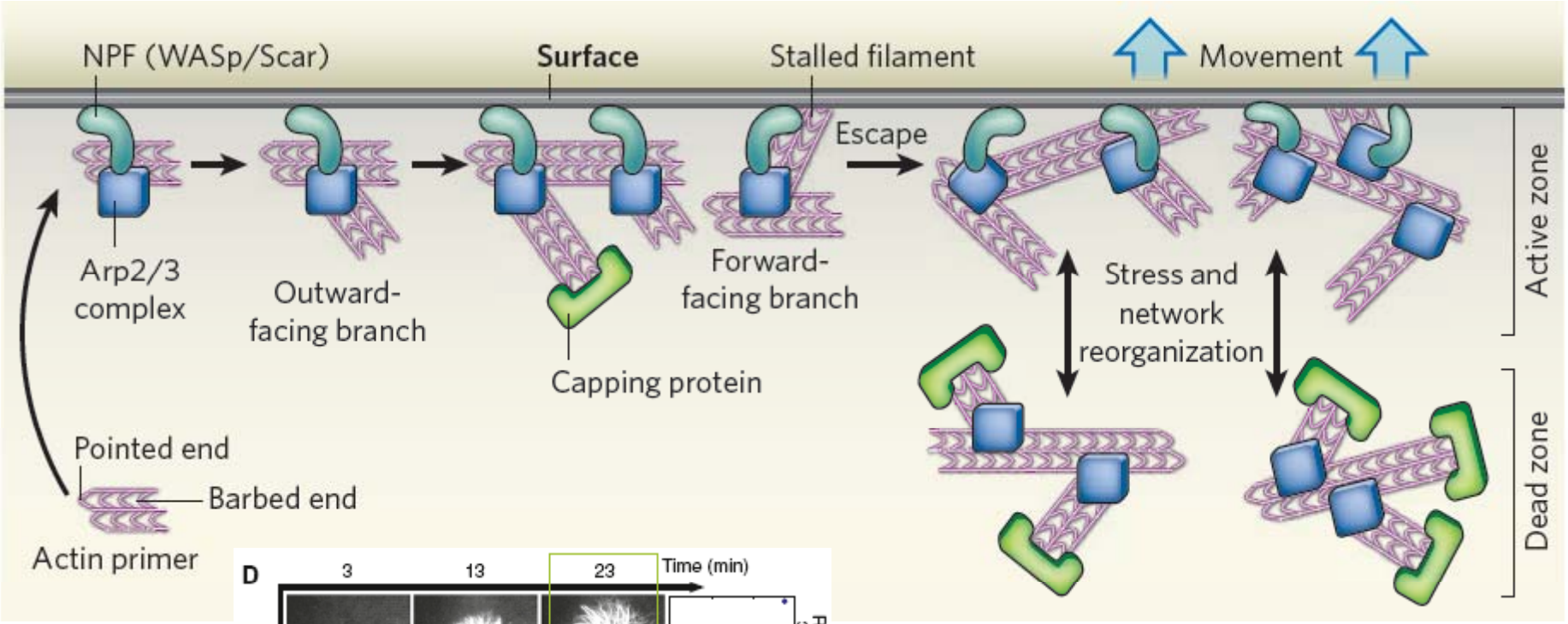
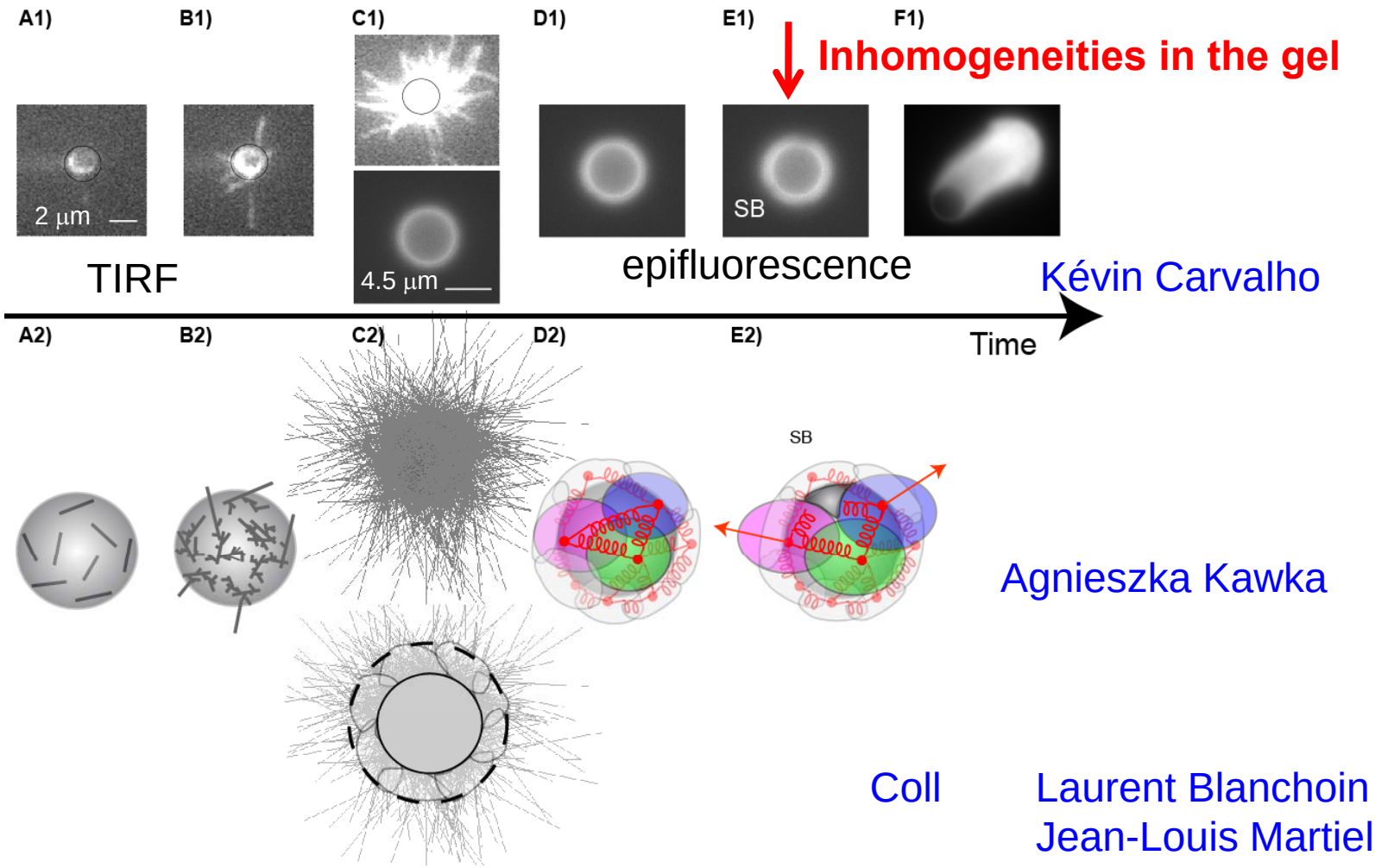
Actin gel growth through branching and capping



[Achard Current Biol 2010, Blanchoin lab]

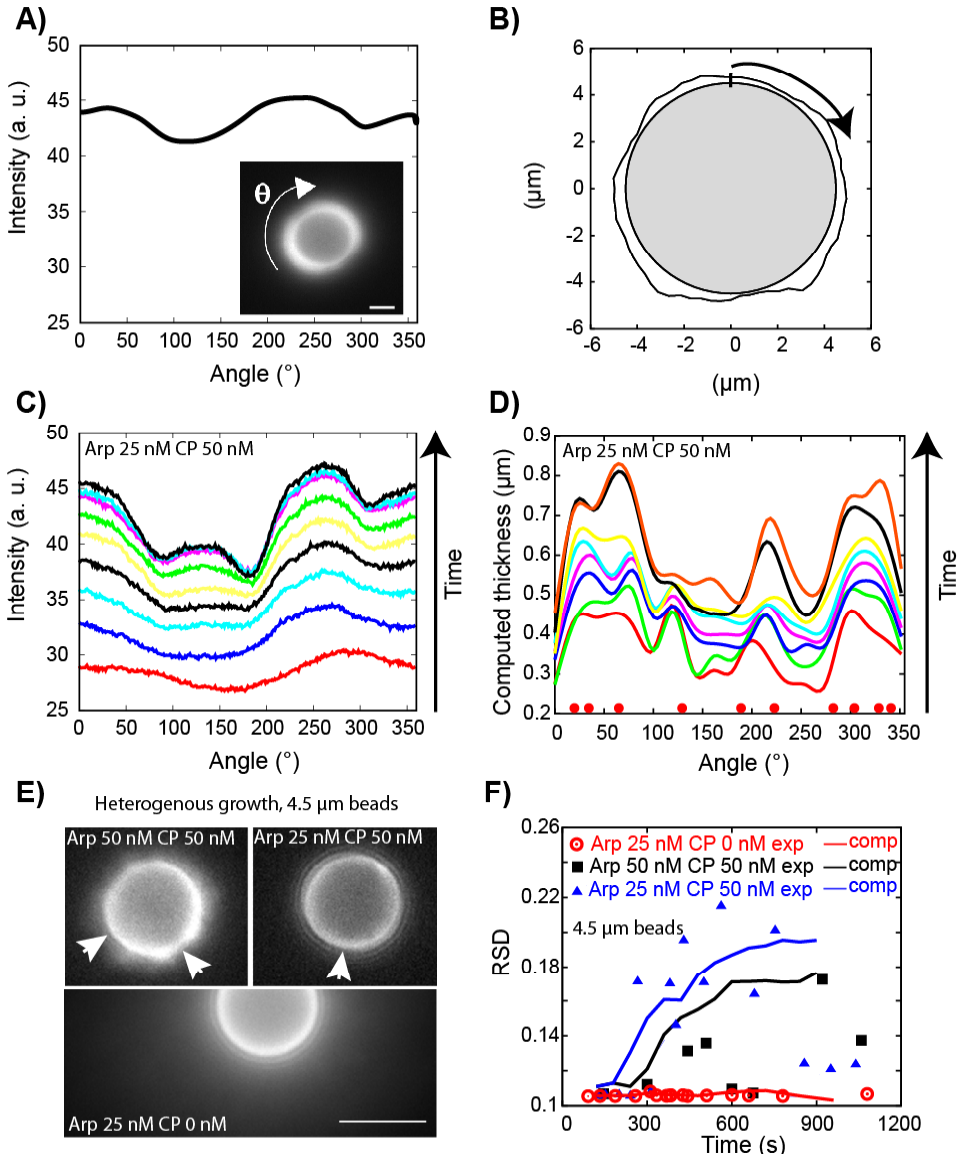
Actin gel growth and stress build up in the presence of Arp2/3 and CP



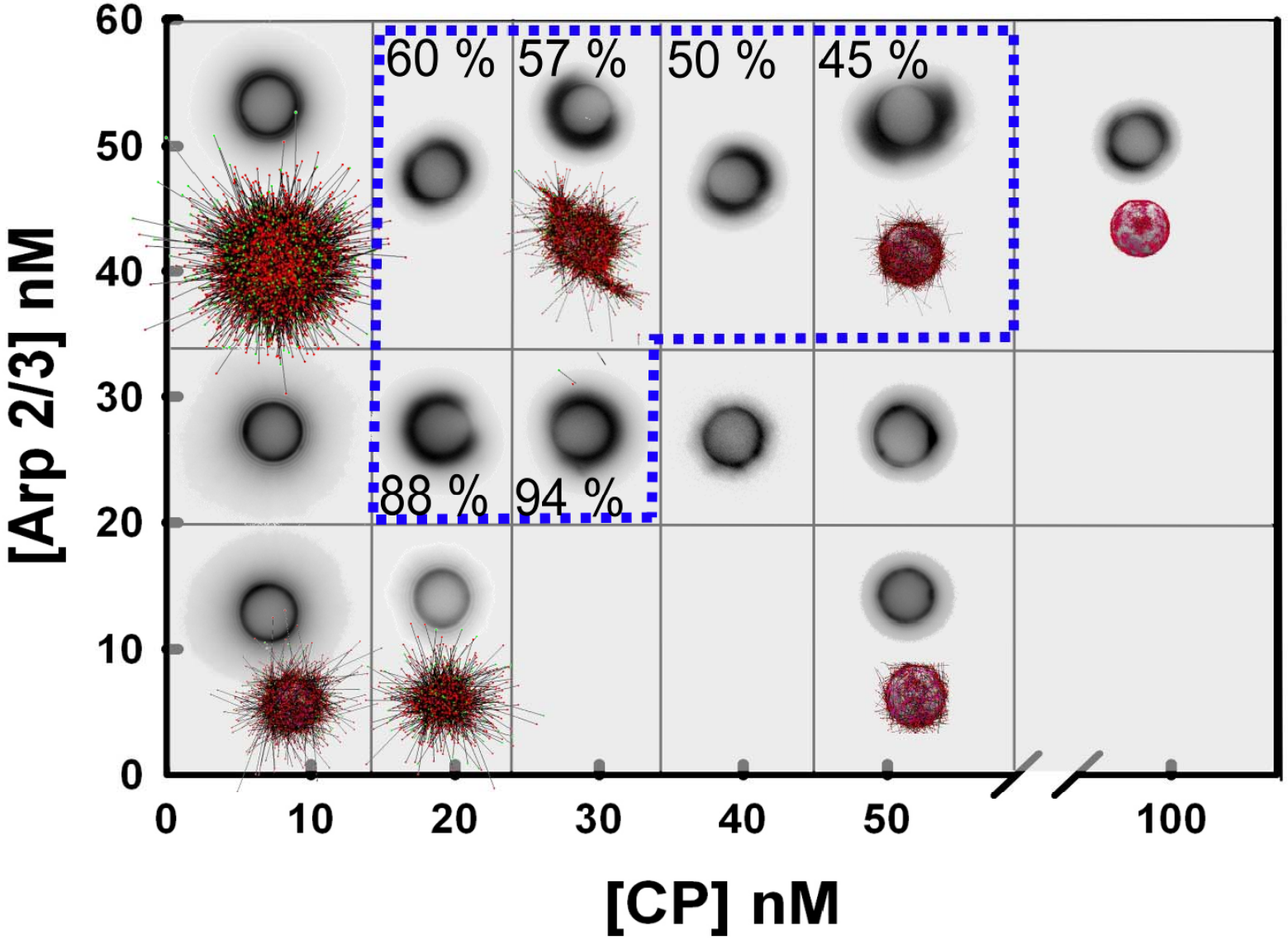
Symmetry breaking does not happen in all Arp2/3 and CP concentration conditions

Actin heterogeneities

No symmetry breaking



Predictive morphology diagram



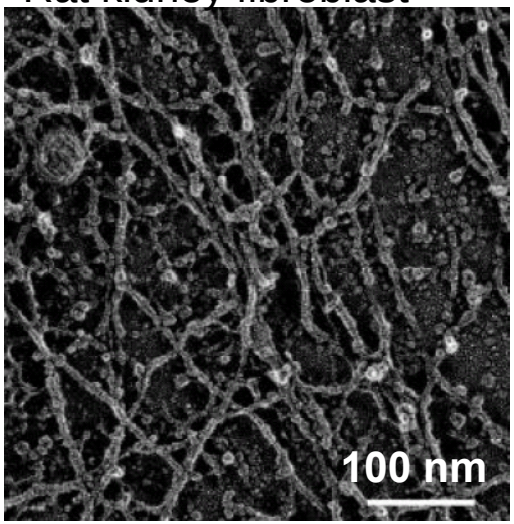
- Formation of actin shells around beads for stress buildup

- **Artificial corteces in liposomes (inside-out geometry of actin shells)**

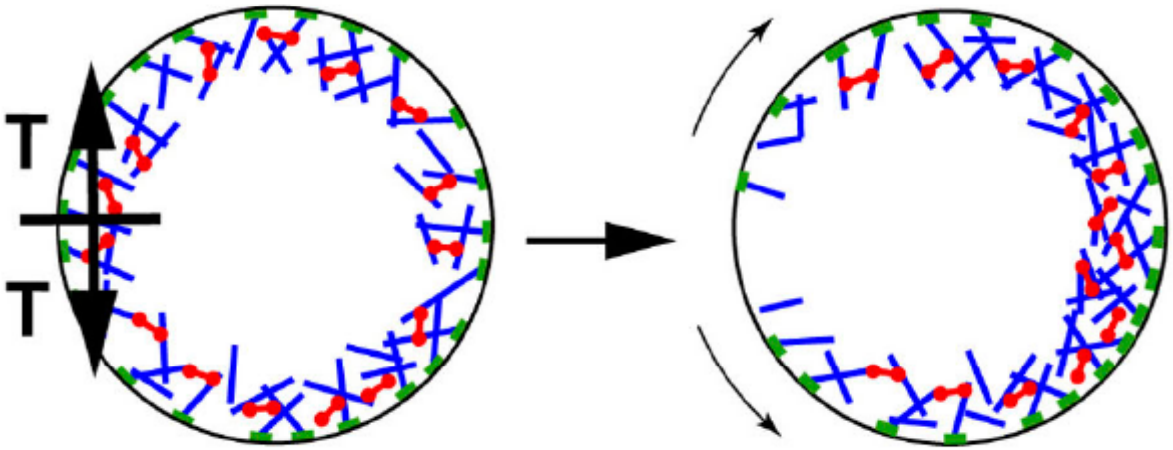
- Mechanical characterisation of artificial corteces (tube pulling)

Mimicking the actomyosin cortex in cells

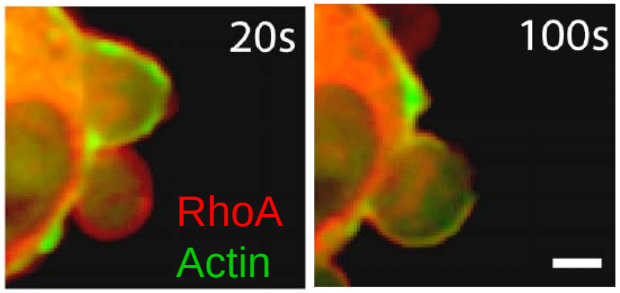
Rat kidney fibroblast



[Morone et al., 2006]



- Filaments next to the membrane
- No specific orientation
- Meshsize ~100nm
- 50nm < thickness < 2µm



[Charras et al., JCB 2006]

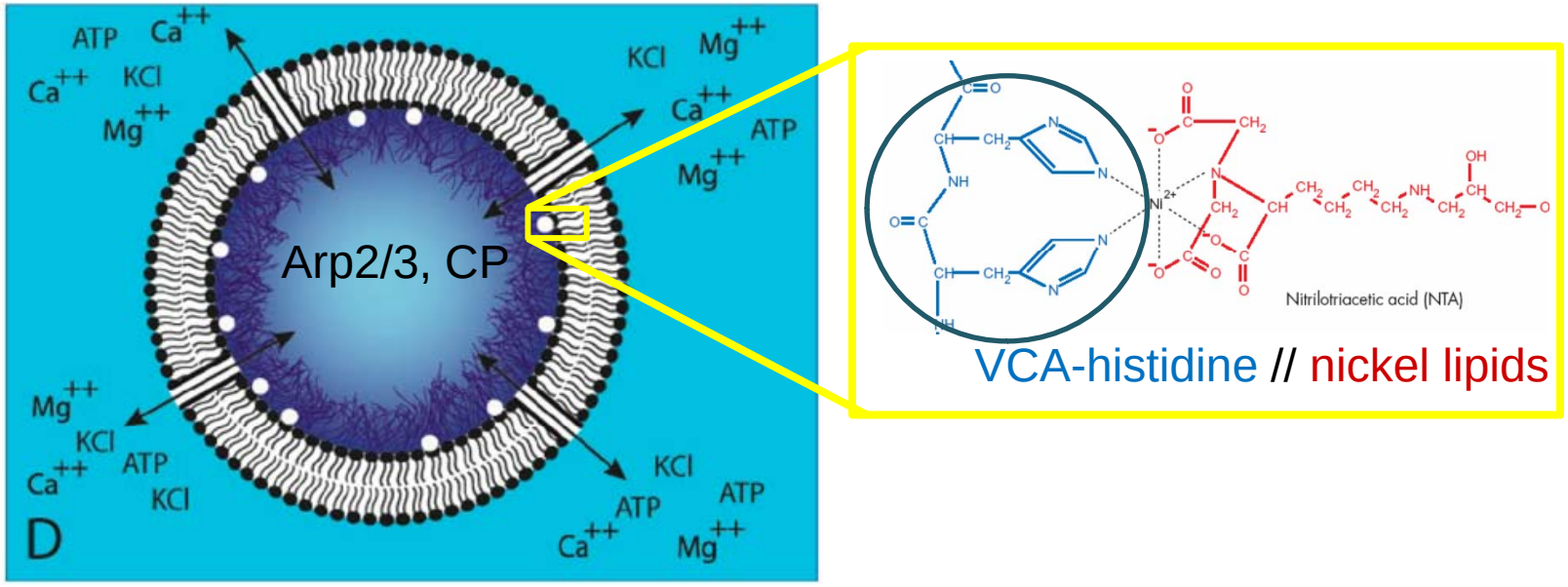
- Nucleation: unclear
- Tethering: ERM proteins
  (Ezrin, Radixin, Moesin)
- Myosin II

Actin polymerisation at the liposome inner membrane

α-hemolysin ~1nm diameter

Cut-off = 3kDa

[Noireaux et al. 2004]



[L.-L. Pontani et al., BJ, 2009]

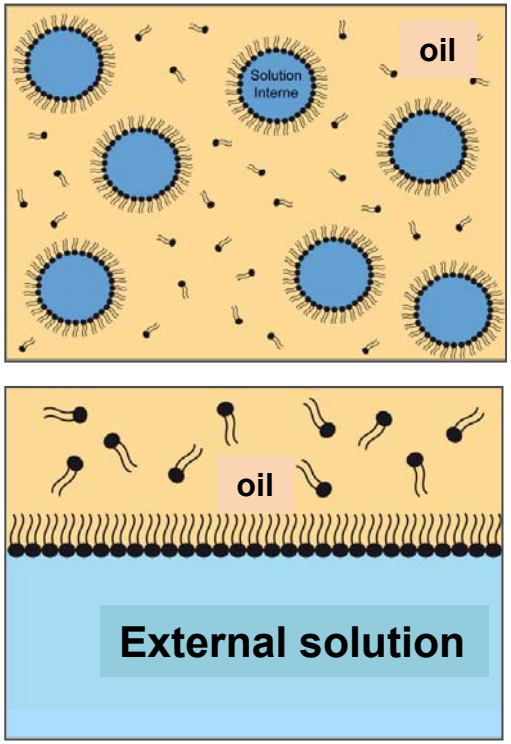
Polymerisation after pore incorporation or upon T° increase

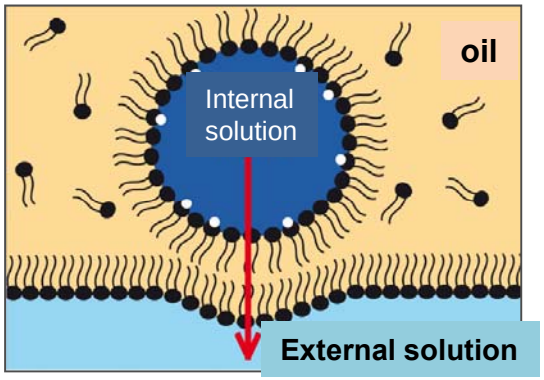
Inverted emulsion technique

[Pautot et al. 2003]

1st interface
➔ Inner layer

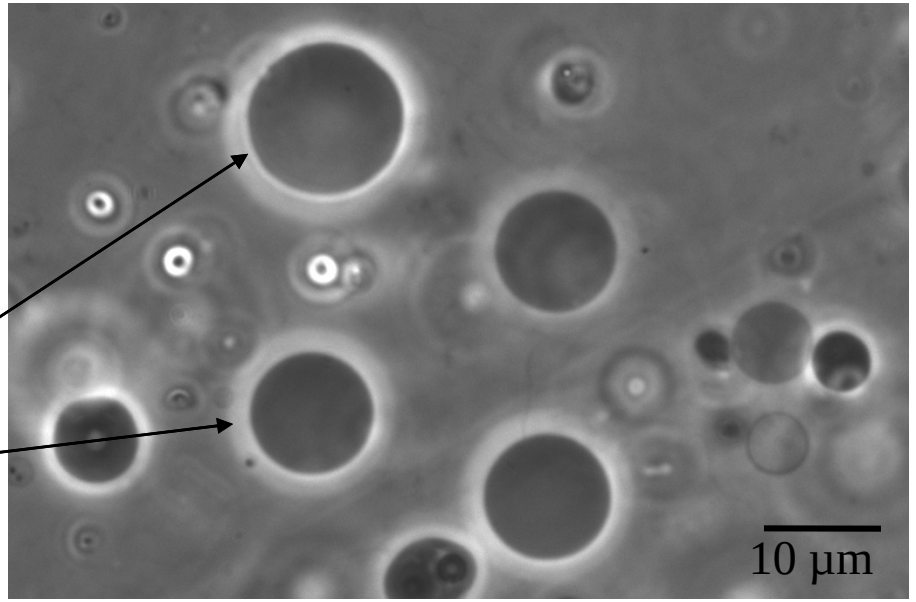
2nd interface
➔ Outer layer





Sucrose inside/glucose outside

➔ High contrast
= effective encapsulation

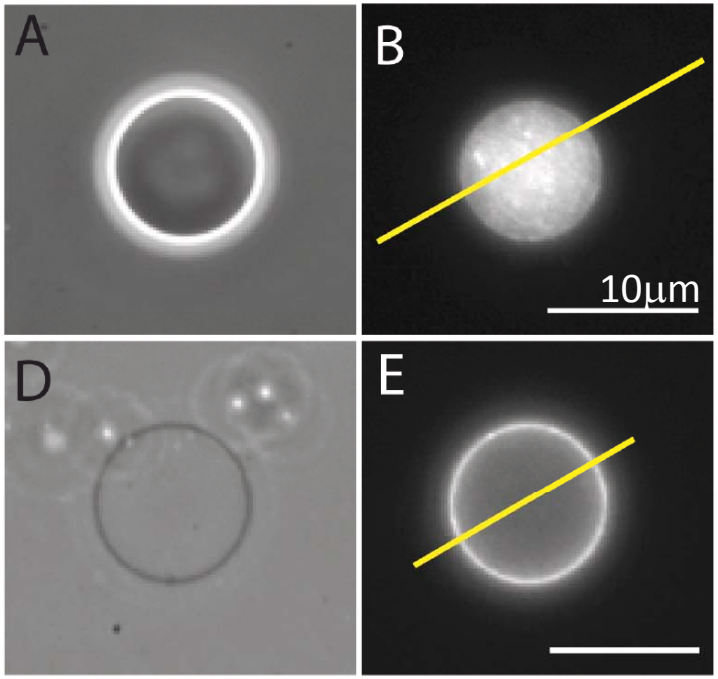


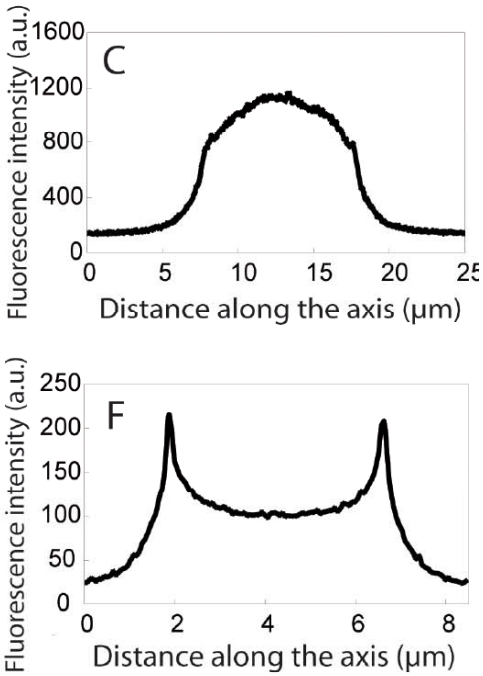
[L.-L. Pontani, BJ 2009]

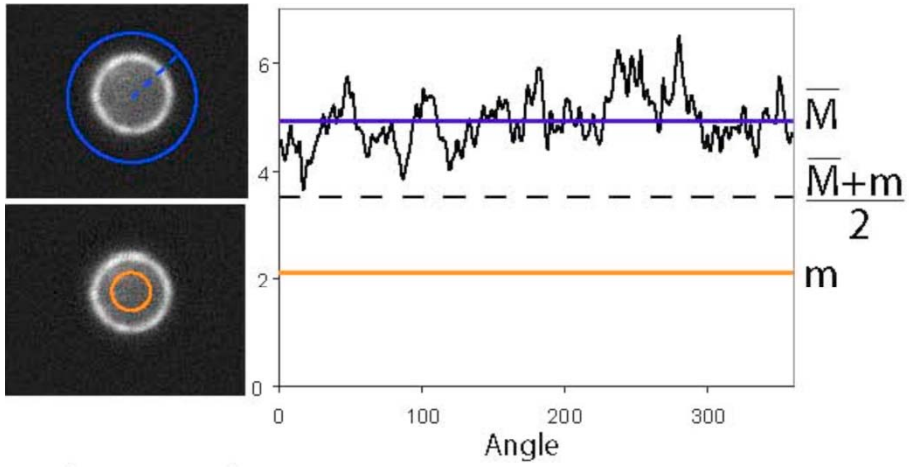
Triggering the polymerisation

Without the pores

With the pores







$$C = \frac{M - m}{M + m}$$

Shell fluorescence if *C>0.01*

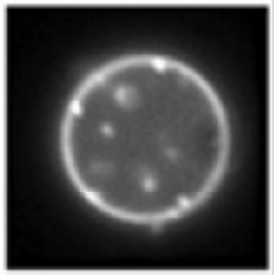
[L.-L. Pontani, BJ 2009]
Without pores, Karine Guevorkian

Artificial corteces

- produce dynamic actin polymerisation
  vanish in LatA treatment
- are specific of the Arp2/3 machinery

[L.-L. Pontani et al., BJ, 2009]

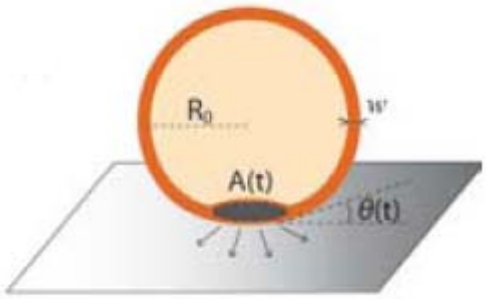
- are able to reproduce the endocytosis of the Shiga toxin

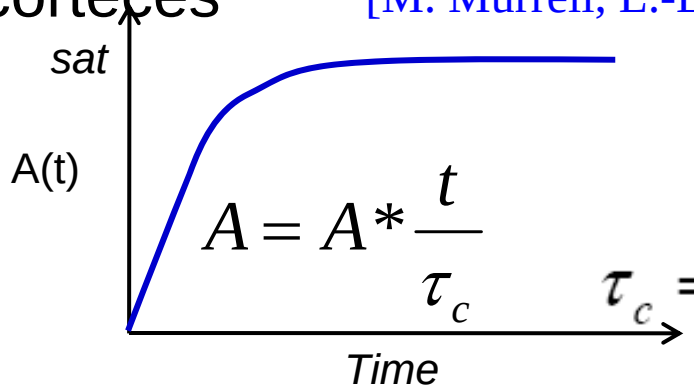


[W. Römer, L.-L. Pontani et al., Cell, 2010]

- spread like cellular corteces

[M. Murrell, L.-L. Pontani et al., BJ 2011]





$$A = A^* \frac{t}{\tau_c} \qquad \tau_c = \frac{\eta_c w}{\sigma_0} \approx 100\,\mathrm{sec}.$$

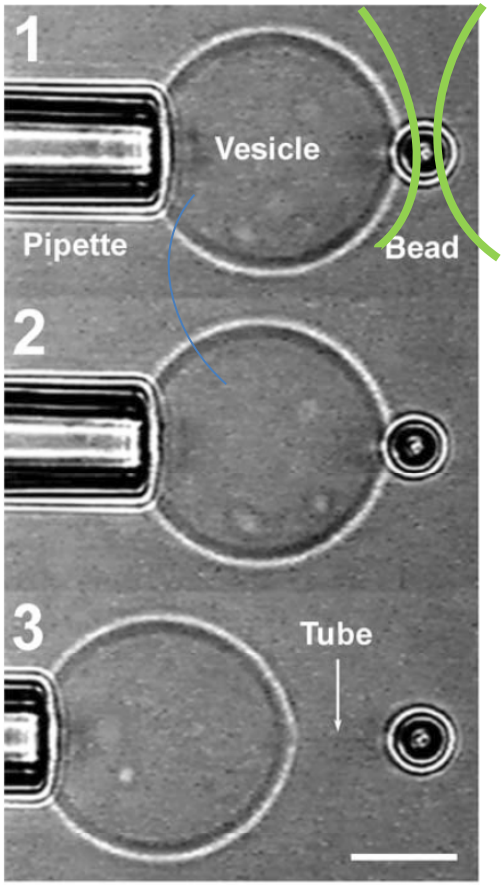
- Formation of actin shells around beads for stress buildup

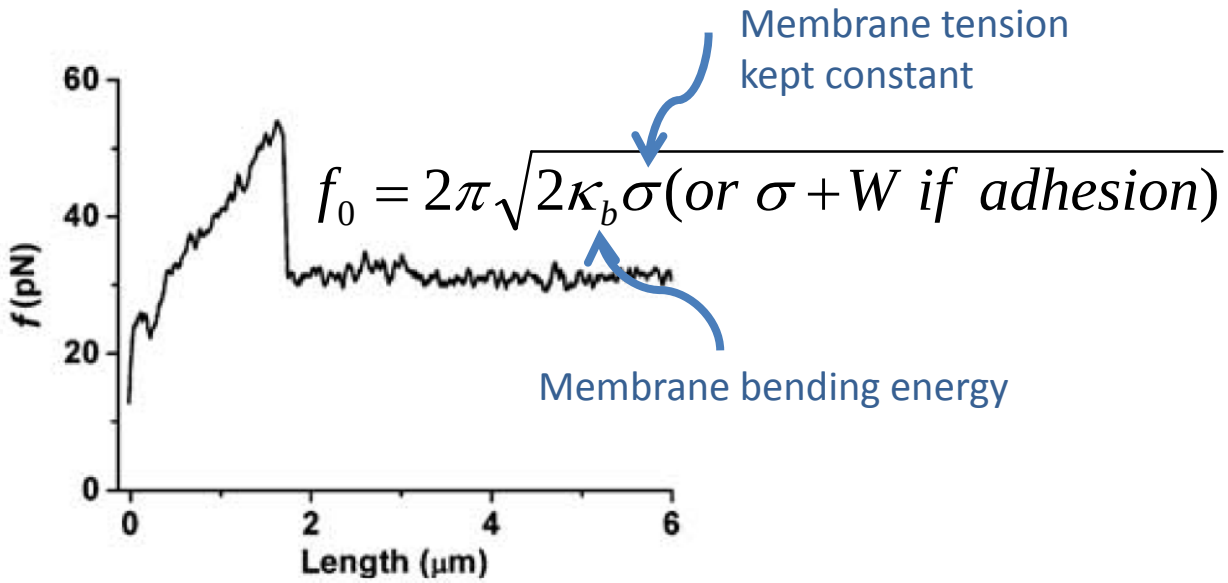
- Artificial corteces in liposomes (inside-out geometry of actin shells)

- **Mechanical characterisation of artificial corteces (tube pulling)**

Tube pulling experiments

for membranes prepared by electroformation





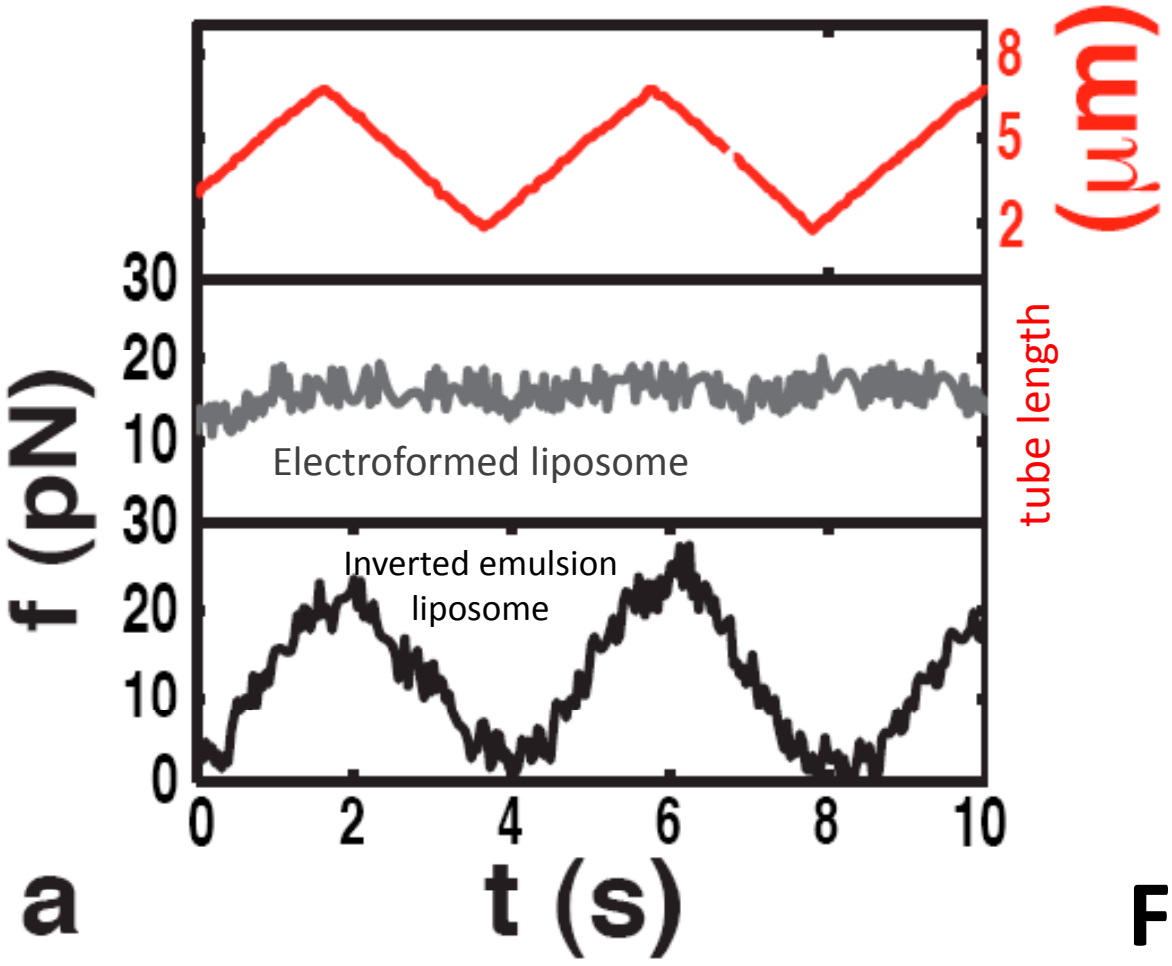
The force for pulling a tube is independent of tube length
for membranes prepared by electroformation,
at constant membrane tension

[A. Roux, EMBO 2005]

For membranes prepared by the inverse emulsion technique???

C. Campillo

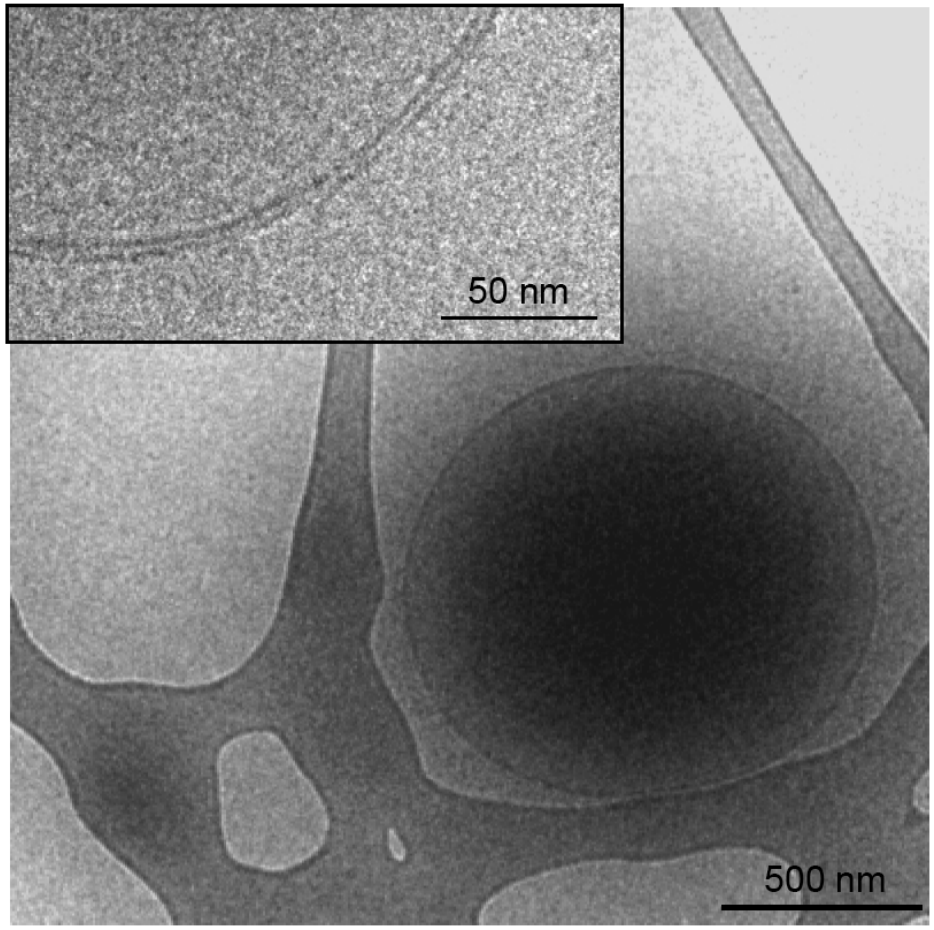
For membranes prepared by the inverted emulsion technique,
force depends on tube length



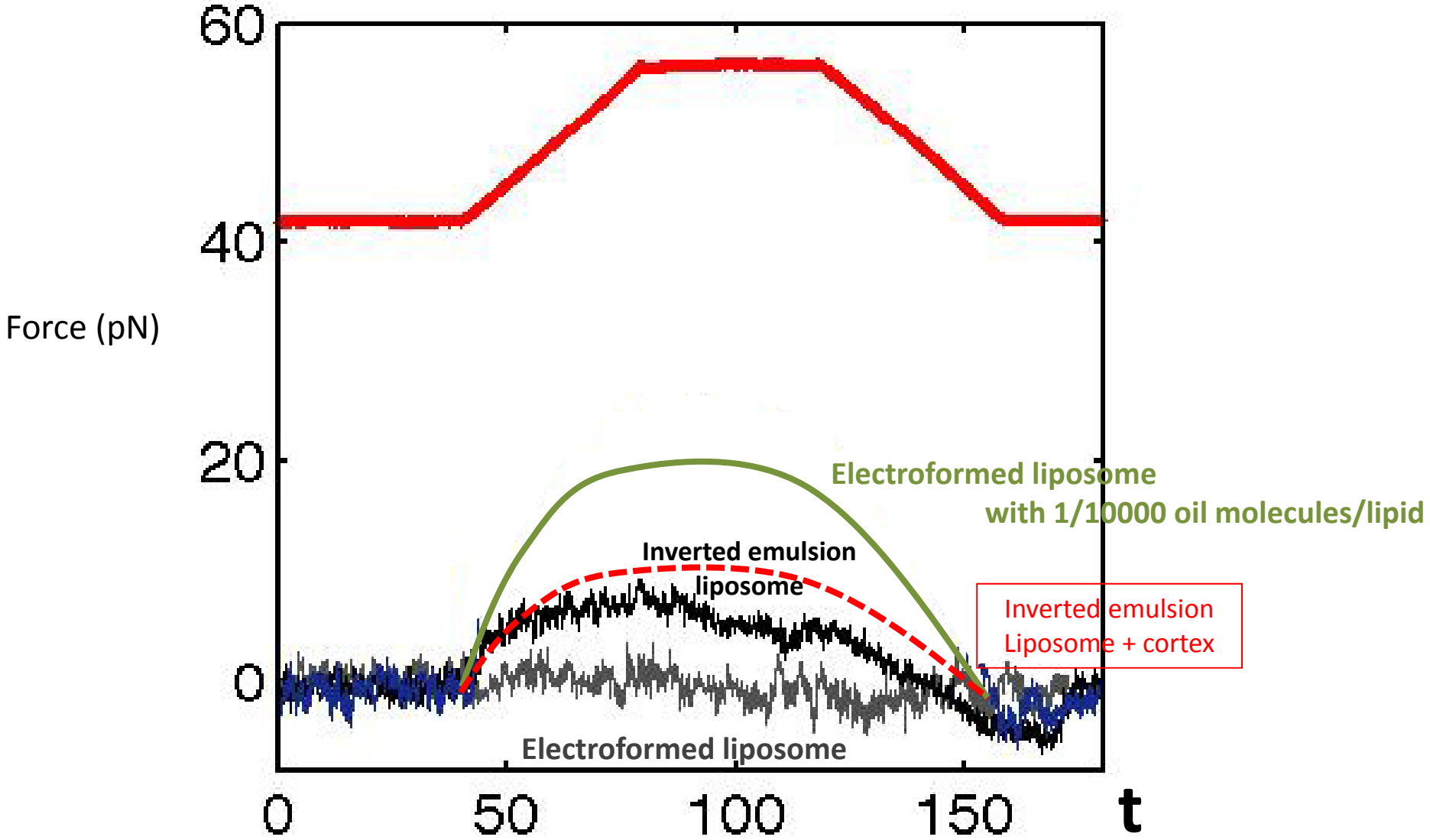
Friction!!

C. Campillo

Thickness: 4.56 ± 0.22 nm (n=54), same as a “pure” lipid bilayer



LL. Pontani, C. Campillo



Take home message:
the difference between electroformed liposomes and cells should not be attributed solely to the cytoskeleton, but mainly to membrane proteins

Conclusion

✓ **Actin shell breakage: stress builds up under specific protein conditions**

✓ **Actin shells can be produced in liposomes**

✓ **The composition of the bilayer membrane controls dynamic mechanical properties (probed by tube pulling)**

Biomimetism of cell movement
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