FONDATION PIERRE-GILLES DE GENNES POUR LA RECHERCHE

PARIS SCIENCES & LETTRES PSL QUARTIER LATIN

From Liquid Crystals to Biology

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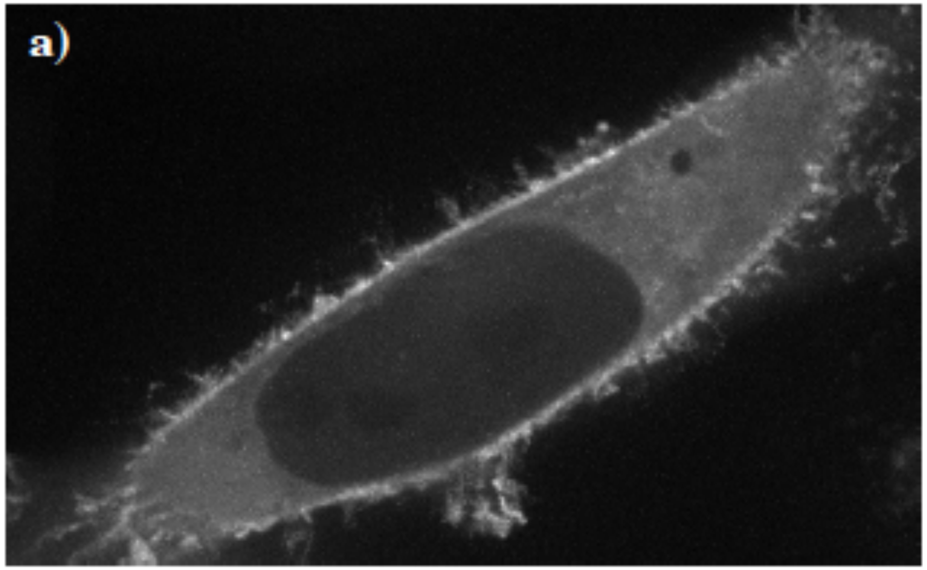
cnrs dépasser les frontières

institutCurie



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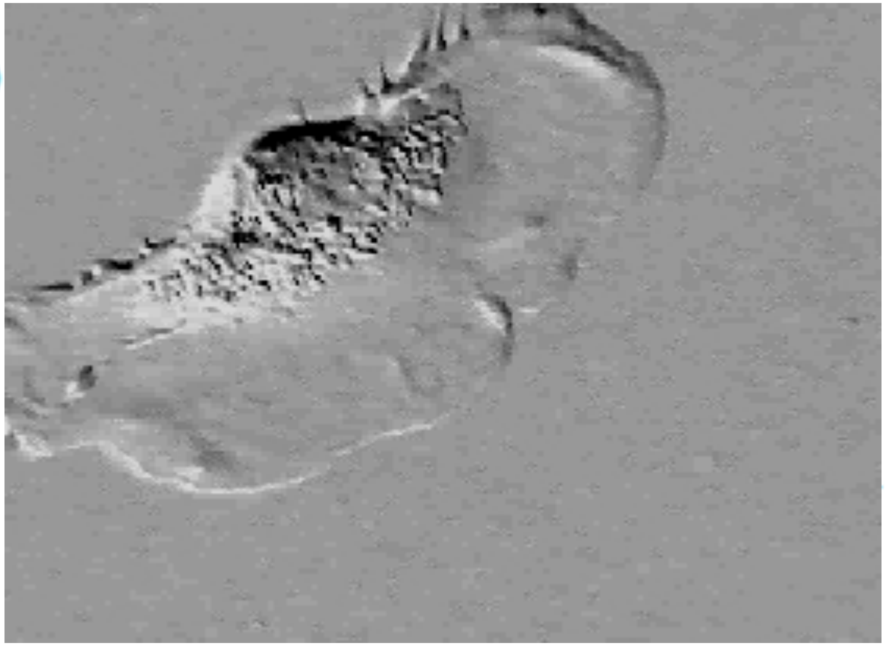
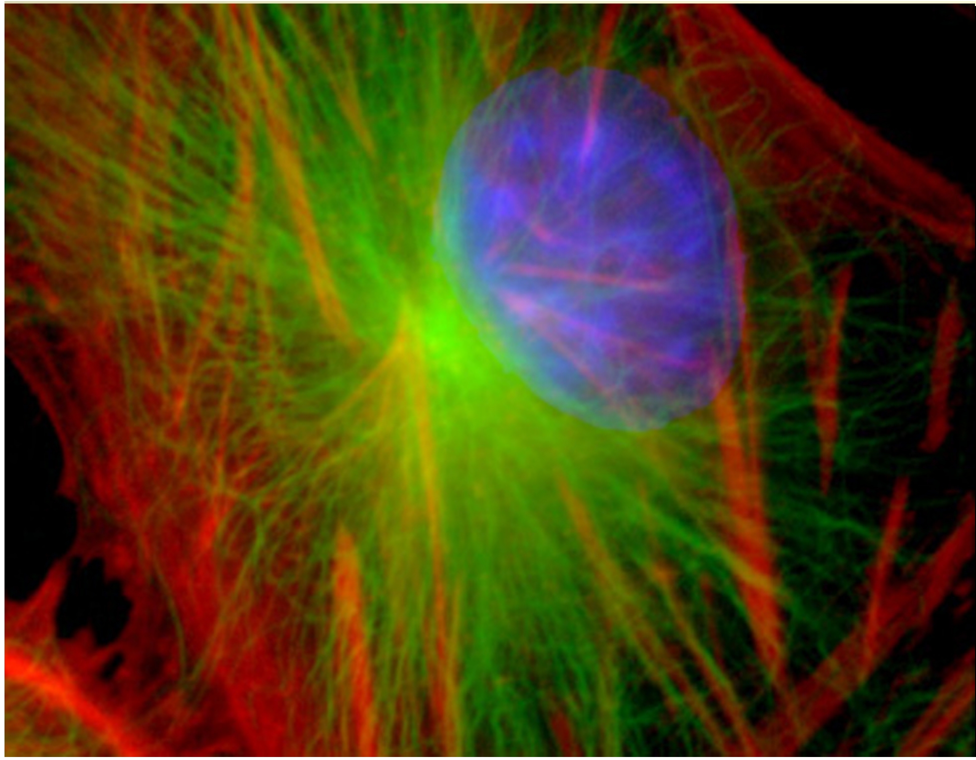
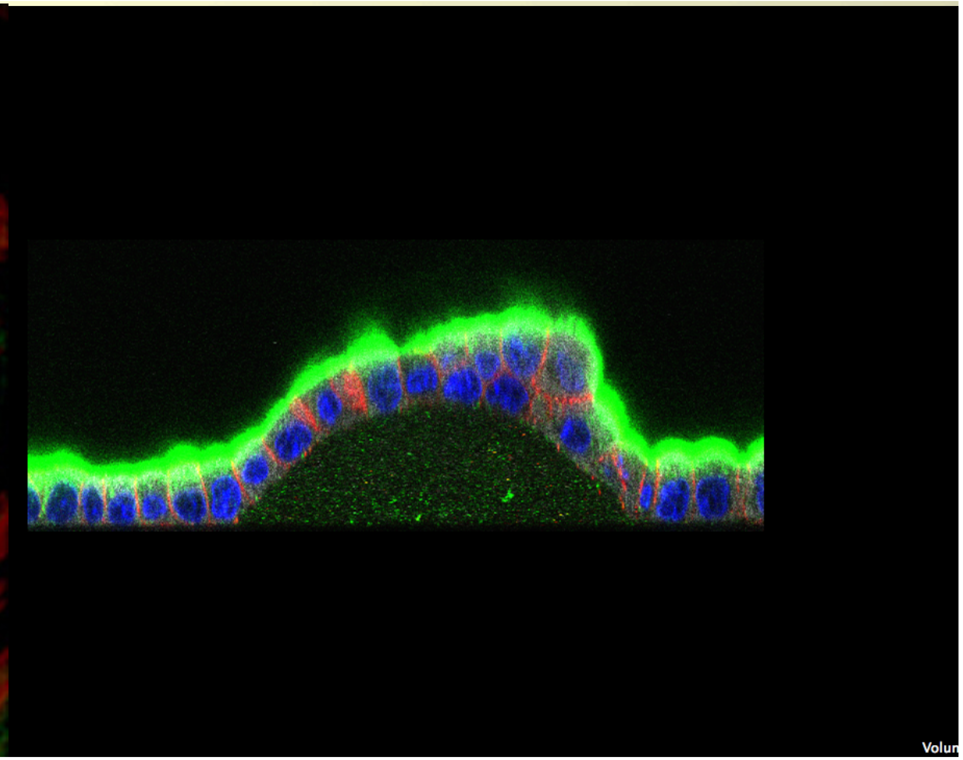
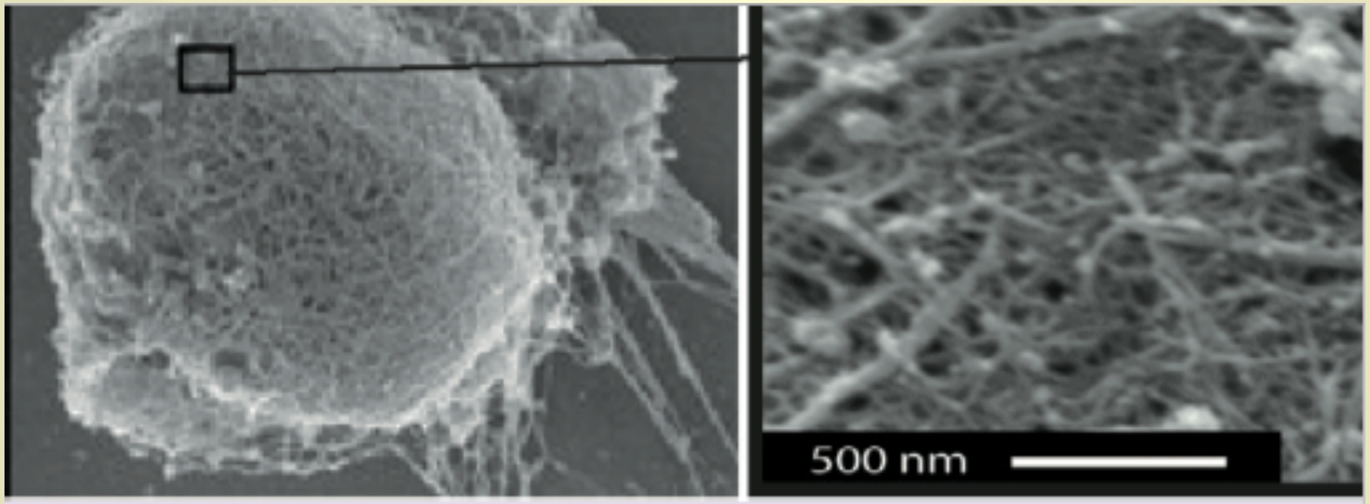


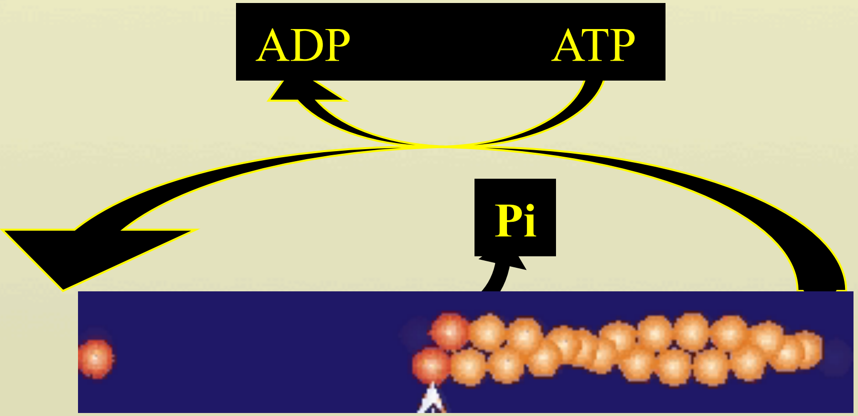




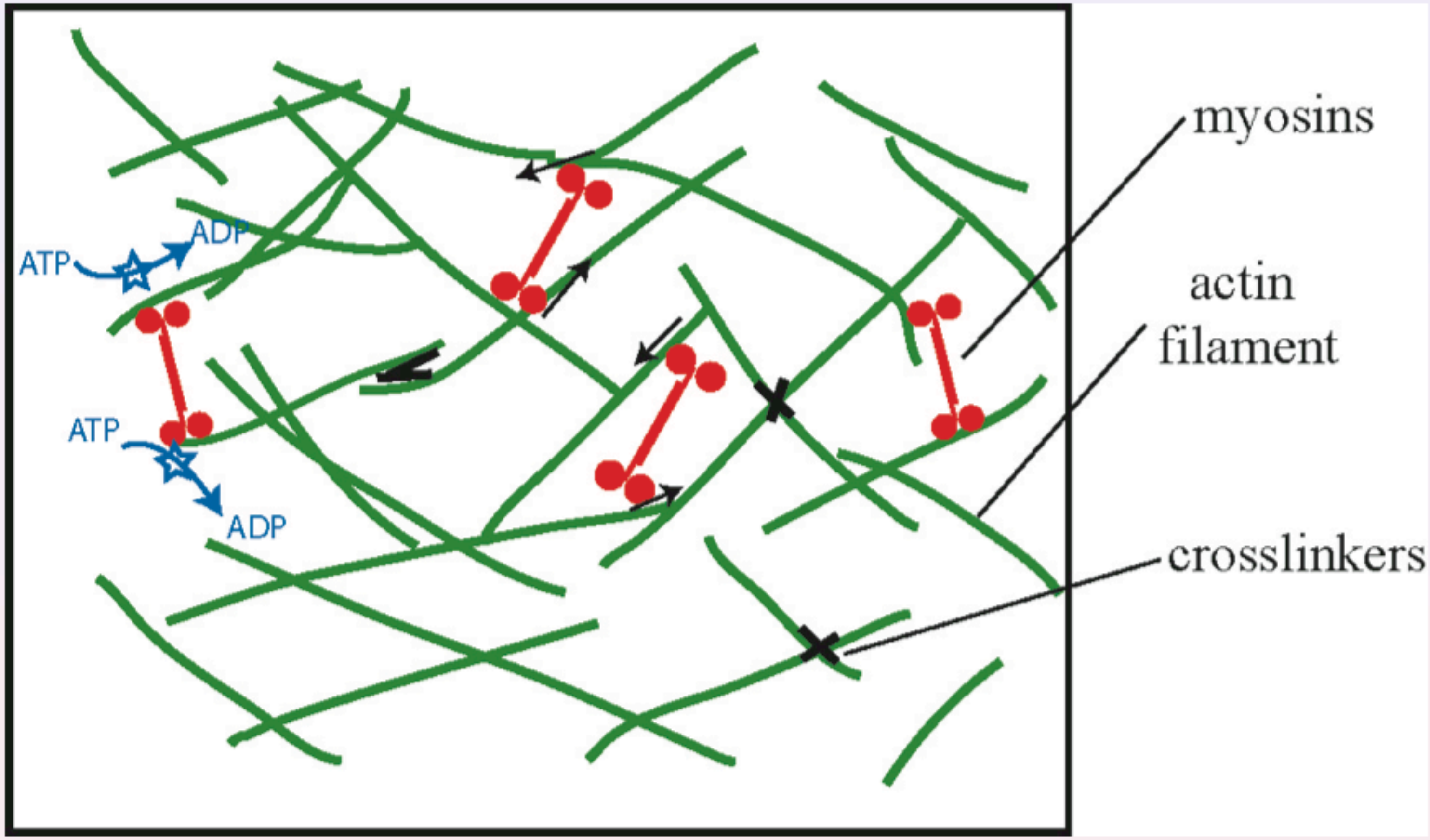
Actin-based dynamics



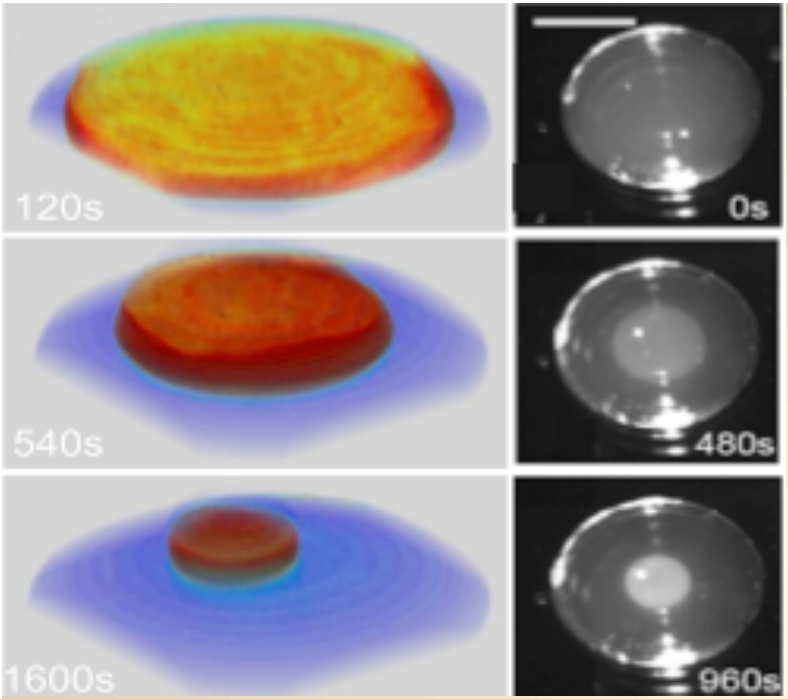
Hela cell, images Charras&al, JCB, 2006



Actin Intrinsic Treadmilling



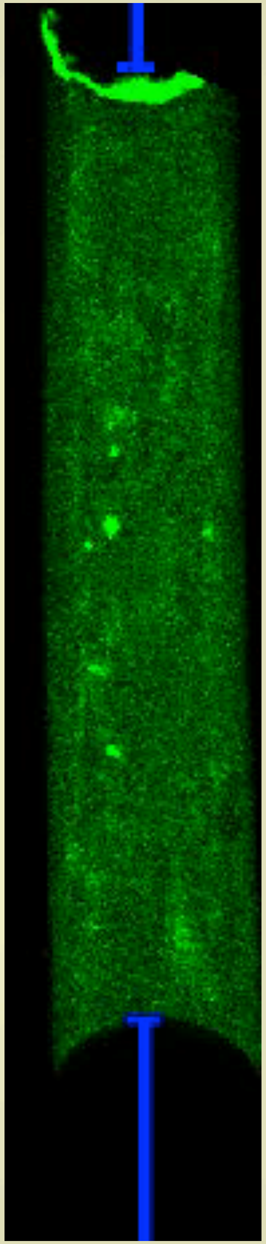
Many microscopic mechanisms



P.M. Bendix et al

Contractility measured in units of Pascal
(*like a pressure or an elastic modulus*)

$$\zeta \ \nabla\mu \cong 10^3 \ \ Pascal$$



How to describe?

P.C. Martin, O. Parodi, P. Pershan

Generalized Hydrodynamics

Conserved quantities, Broken symmetries

- Actin (monomer+polymer)
- Myosin (bound, unbound)
- Momentum (force)
- Polarization

Harvard Choice

$Stress \quad \sigma$

$Orientation \quad dynamics$

$ATP \quad consumption \quad rate$

$Fluxes \quad (myo\sin, actin, cytosol)$

$Velocity \quad Gradients$

$Orientation \quad direction \quad gradients \quad \nabla P$

$Chemical \quad potential \quad difference \quad \Delta\mu = \mu_{ATP} - \mu_{ADP} - \mu_{P_i}$

$Chemical \quad potential \quad gradients \quad \nabla\mu_{myo}, \nabla\mu_{act}, \nabla\mu_{cyt}$

Find

Short time: Physics of gels + motors

$Maxwell\ Time : \tau_M$

Long time: Physics of liquid crystals + Motors

Motors?

Contractility

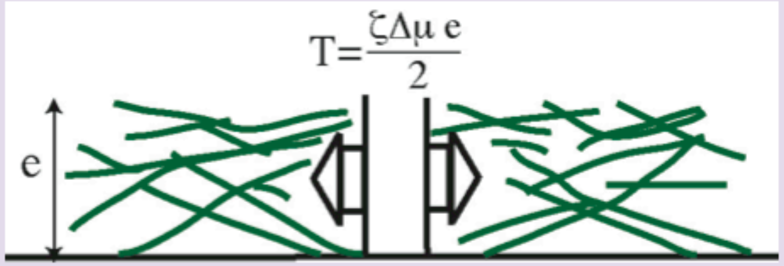
Self-organisation

Instabilities at long length scale

$$
\begin{aligned}
\sigma_{\alpha\beta} &= 2\eta v_{\alpha\beta} - \beta_1 H_{\alpha\beta} + \zeta \Delta\mu Q_{\alpha\beta} \\
\frac{D}{Dt} Q_{\alpha\beta} &= \beta_1 v_{\alpha\beta} + \frac{1}{\beta_2} H_{\alpha\beta} + \lambda \Delta\mu Q_{\alpha\beta}
\end{aligned}
$$

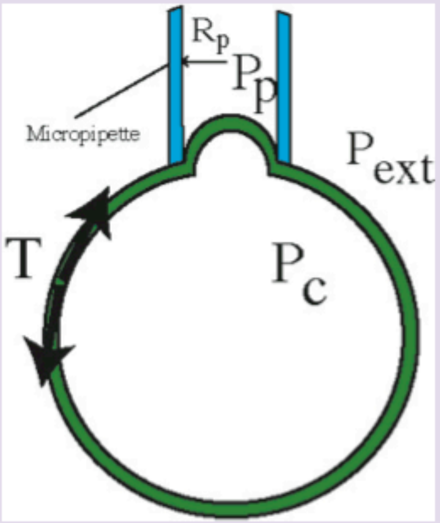
$$
H_{\alpha\beta} = -\frac{\delta \mathcal{F}}{\delta Q_{\alpha\beta}}
$$

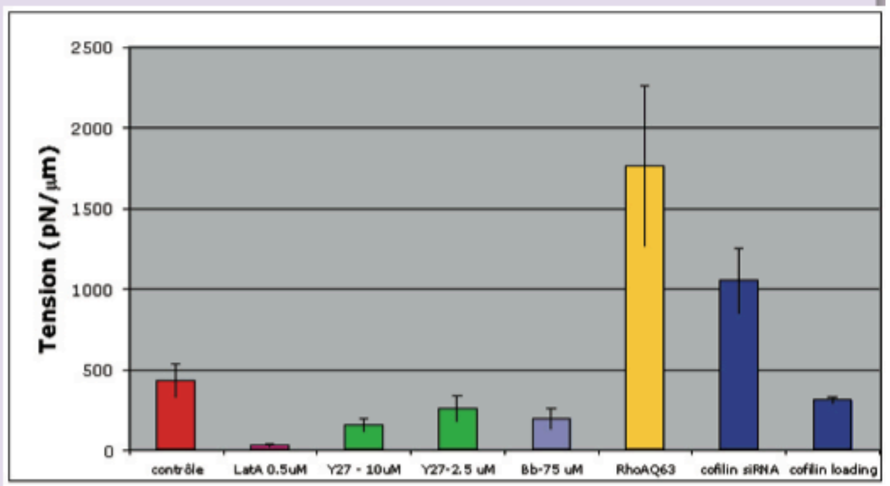
Myosin give rise to a global tension



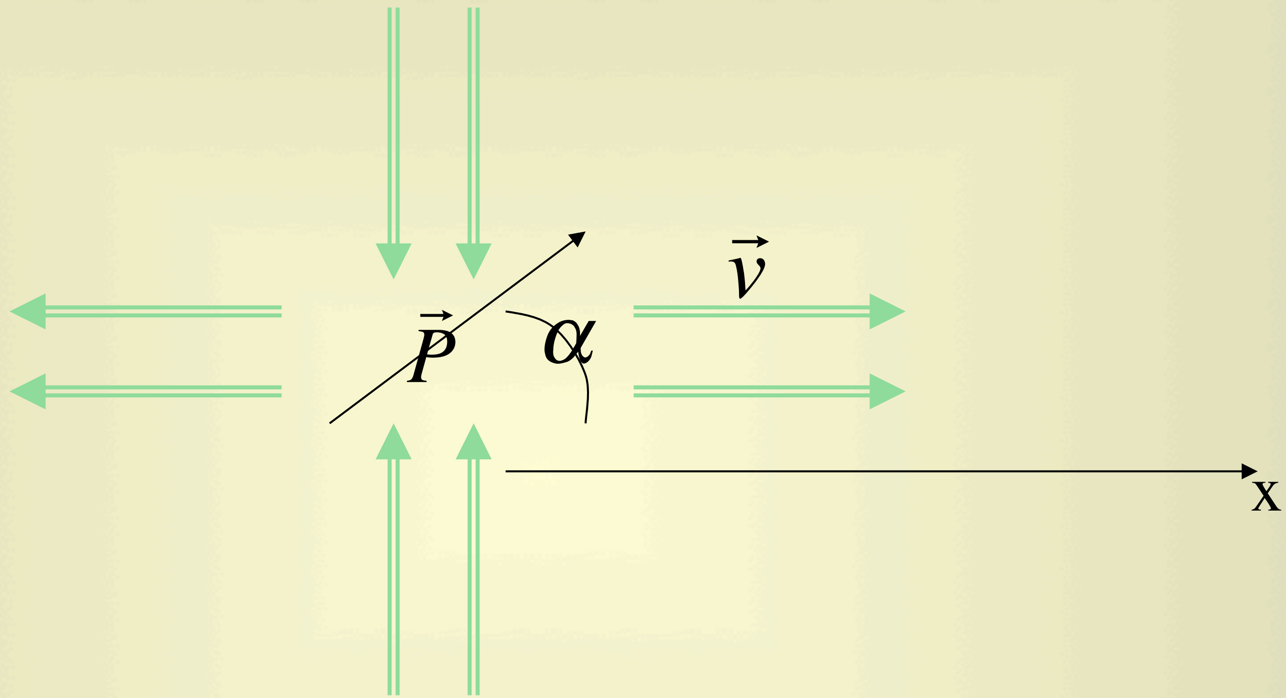
$$T = \frac{\zeta \Delta \mu e}{2}$$
$$T \sim c_m \frac{v_p}{k_d}$$

Micropipette aspiration experiment *U. Schulze, J. Roensch, E. Paluch*





Pure Shear (Elongational Flow)

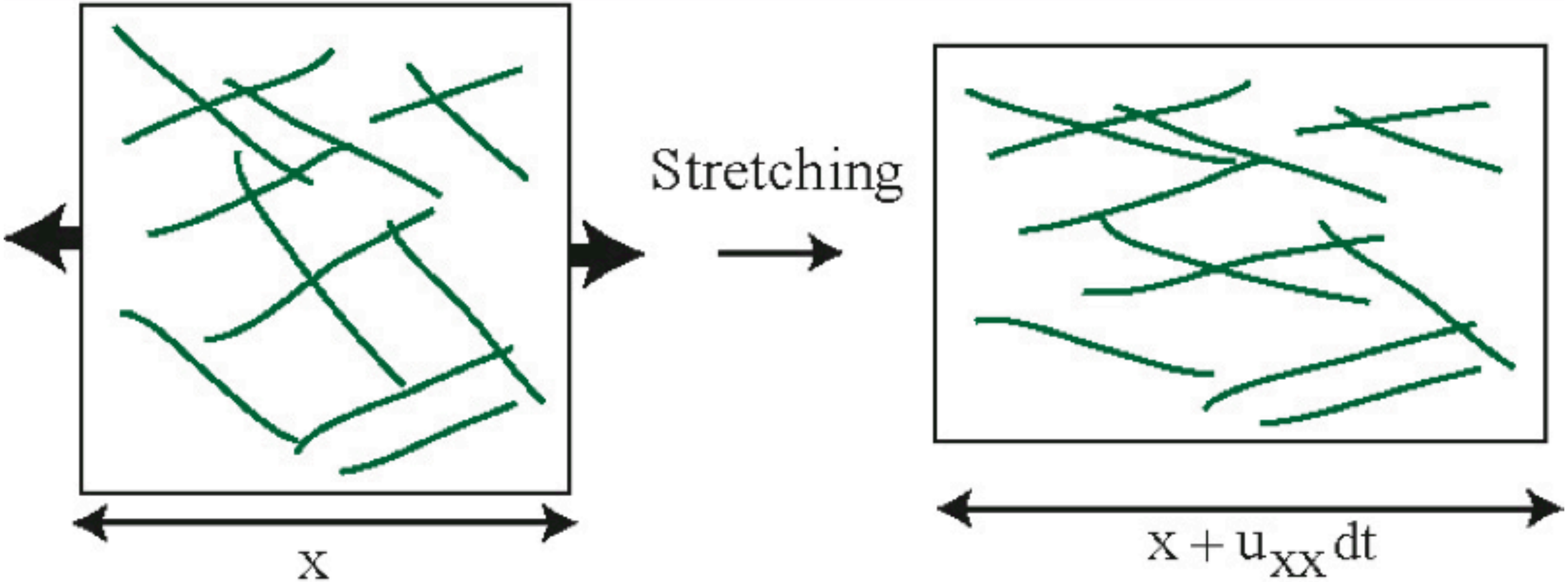


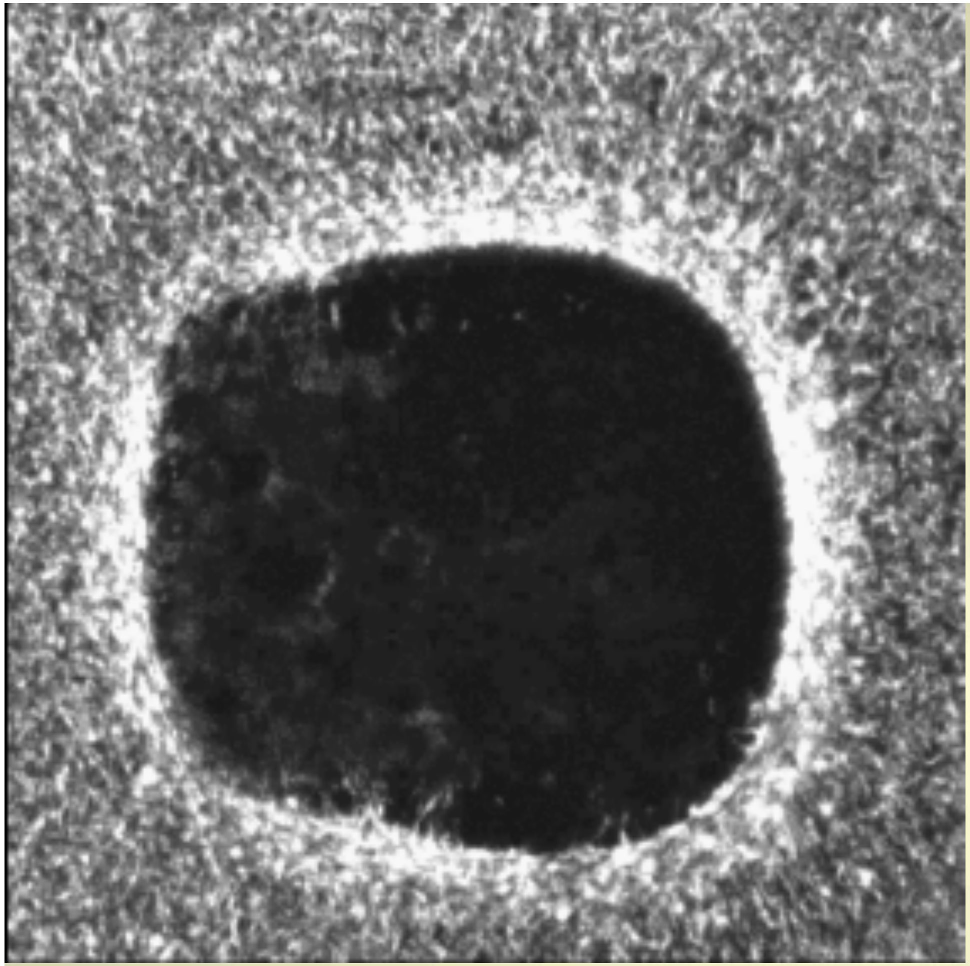
$$\frac{\partial \alpha}{\partial t} = -v_1 \sin(2\alpha)\partial_x v_x + ...$$

$\alpha = 0$ Stable if: $\alpha\ \partial_x v_x > 0$

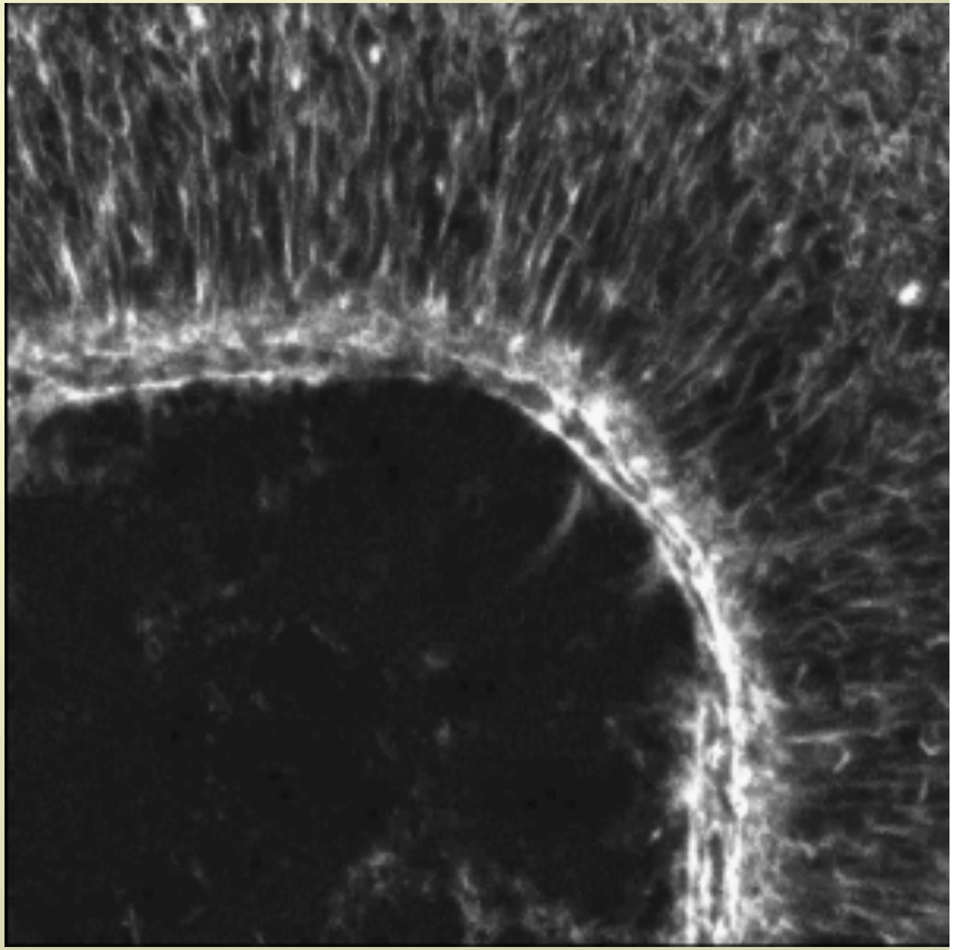
$\alpha = \frac{\pi}{2}$ Stable if: $\alpha\ \partial_x v_x < 0$

$$Actin: \quad \alpha = 0$$





Xenopus Egg Wound healing



C.A. Mandato, W.M. Bement