

La neurita: Una cuerda entretenida

Chantal Tassius¹, Roberto Bernal², Charles Greenberg³,
Pramod Pullarkat⁴ & Francisco Melo¹

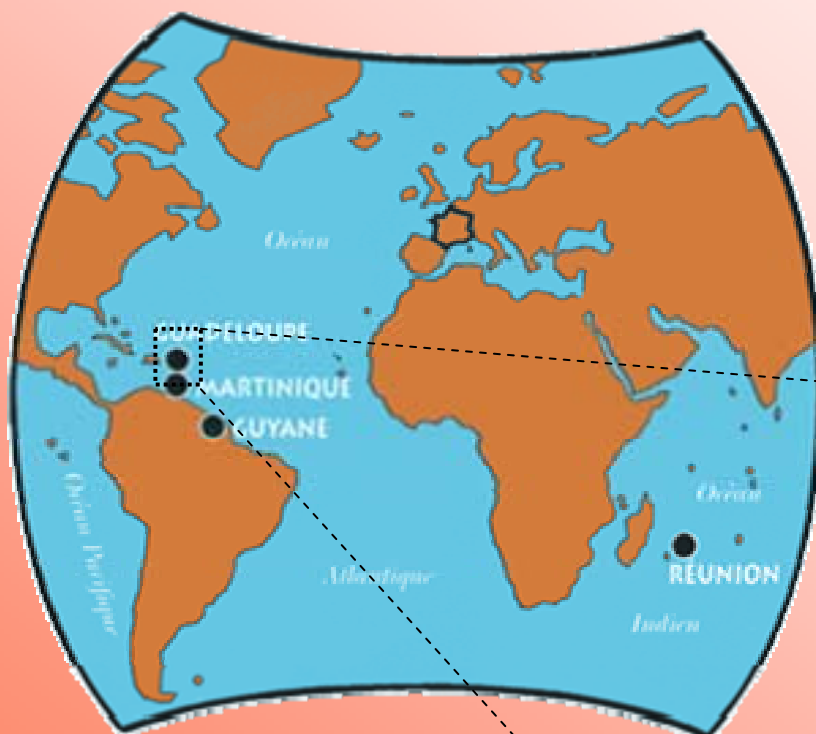
¹ Laboratorio de Física No Lineal, Universidad de Santiago (Chile)

² Department of Organismic and Evolutionary Biology, Harvard University (USA)

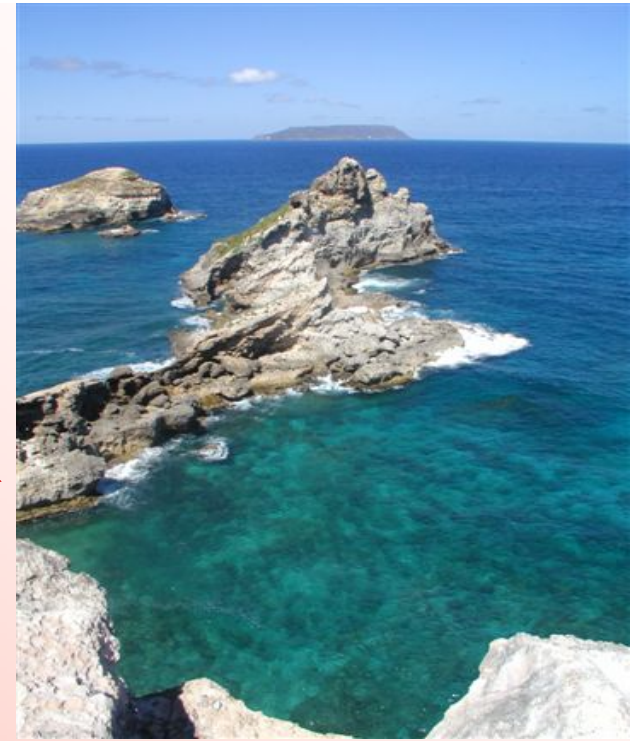
³ University of Chicago, Chicago (USA)

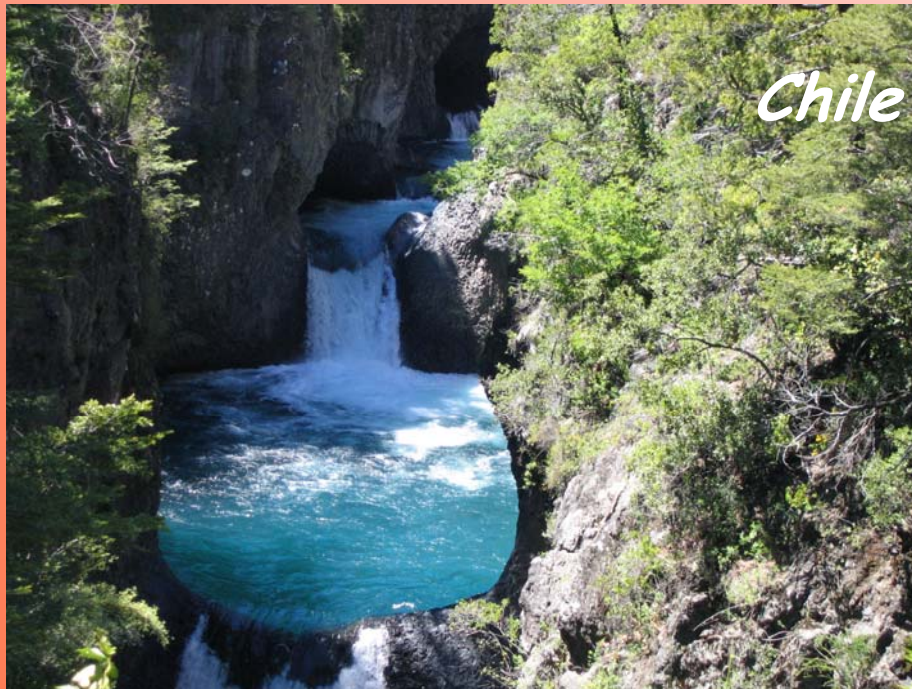
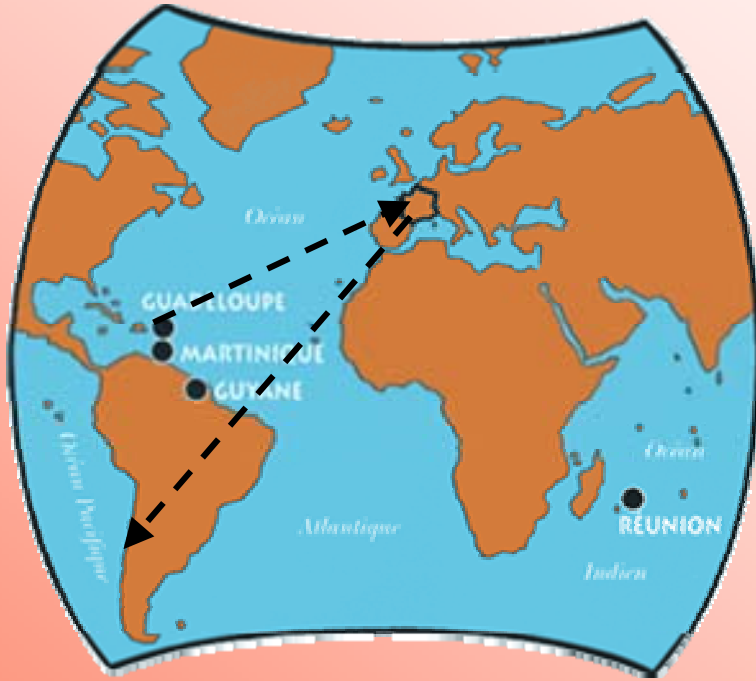
⁴ Bayreuth University, Bayreuth (Alemania)

¿Quién soy ?

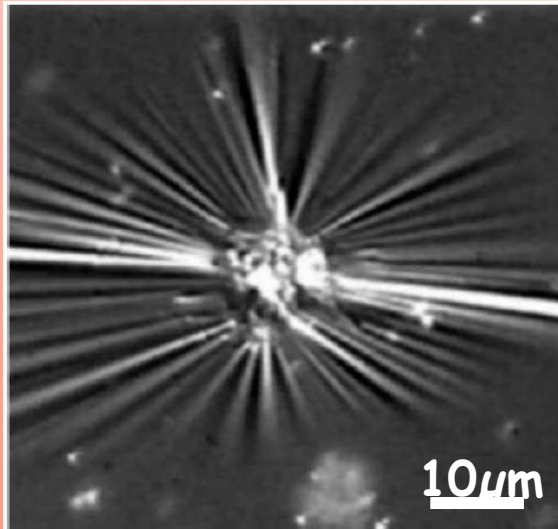


Guadalupe...





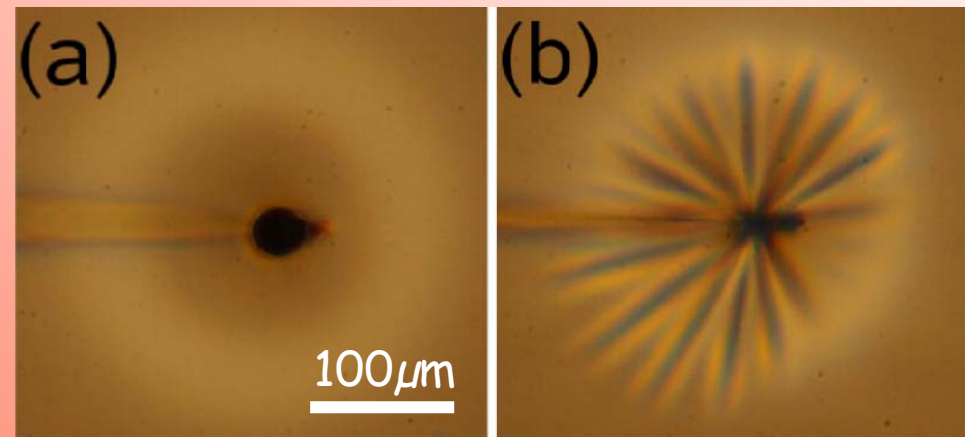
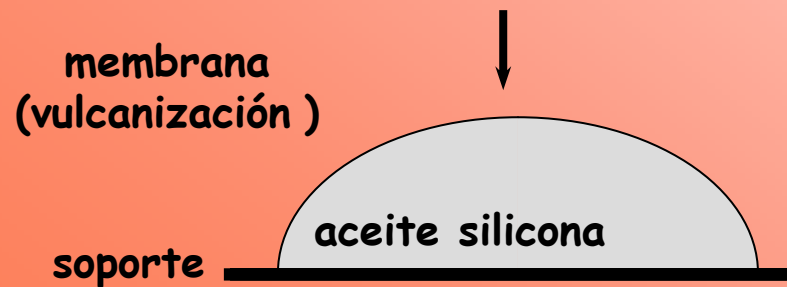
¿ Cómo nacieron los proyectos?



Contracción radial de un **fibroblasto** moriéndose

fibroblasto : célula involucrada al cicatrizar las heridas

K.Burton, D.L.Taylor, Nature, 385, 1997



Biofísica en el laboratorio de Física no lineal,
USACH

Tesis de Roberto BERNAL con F. MELO

**Elasticidad de
membranas delgadas**

con J.-Ch. Géminard,
Laboratoire de Physique
de l'Ecole Normale de
Lyon, France

**Mecánica de los
sistemas biológicos**

con Pramod Pullarkat,
Bayreuth University
Alemania

Índice de la presentación

- El sistema biológico
- El dispositivo experimental
- Los resultados
- El modelo
- Perspectivas

Índice de la presentación

- El sistema biológico

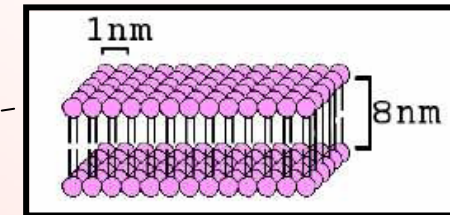
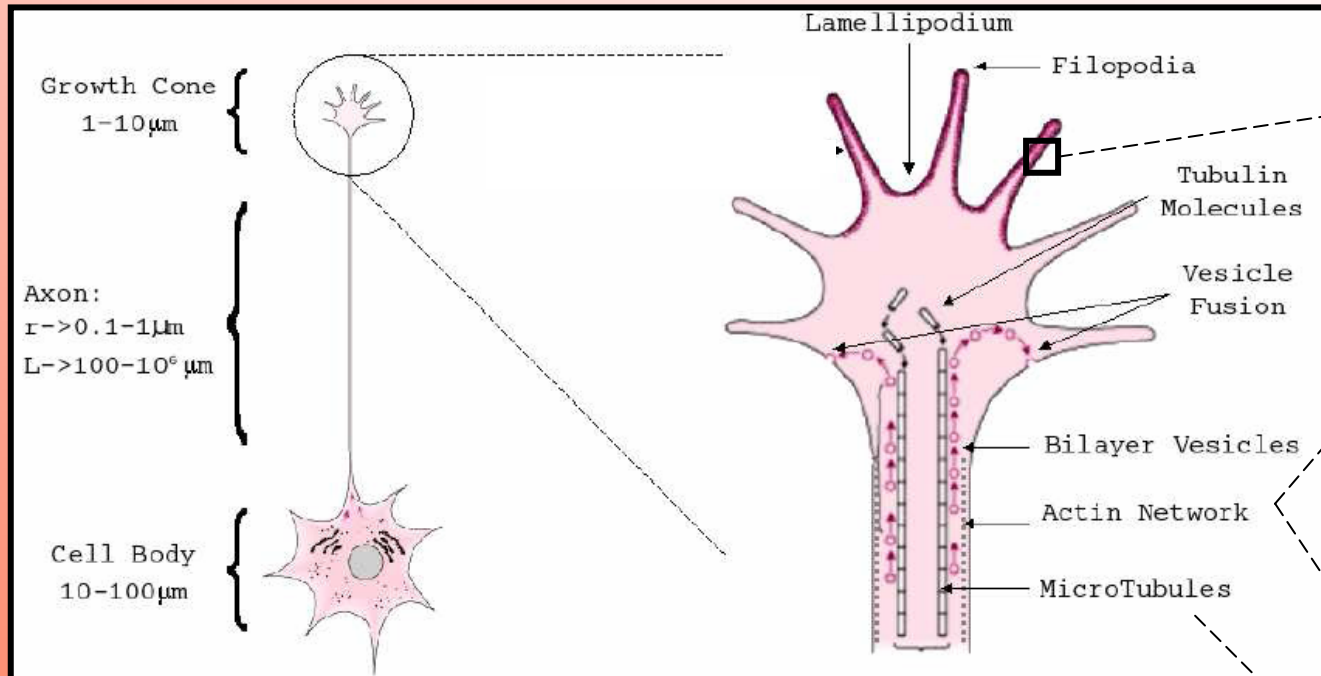
- El dispositivo experimental

- Los resultados

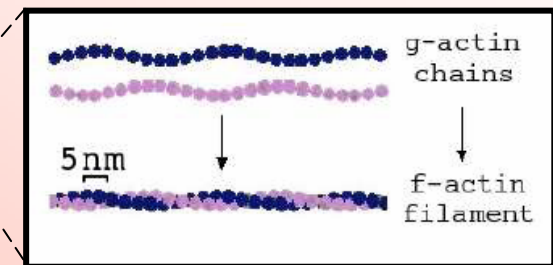
- El modelo

- Perspectivas

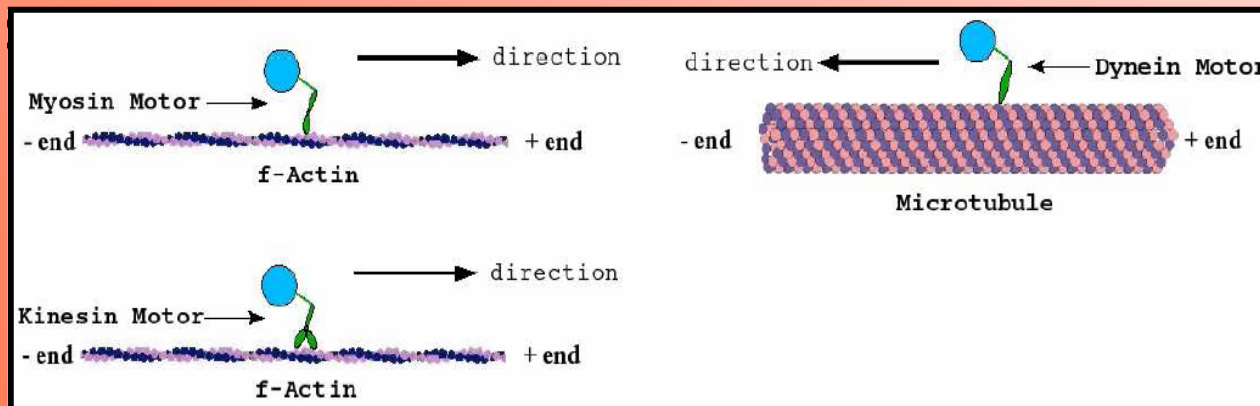
Generalidades sobre las neuronas



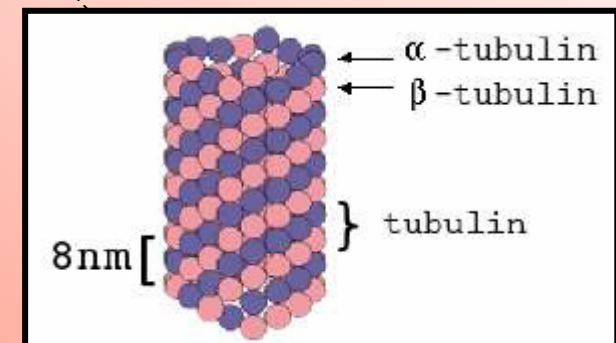
membrana celular



red de actina

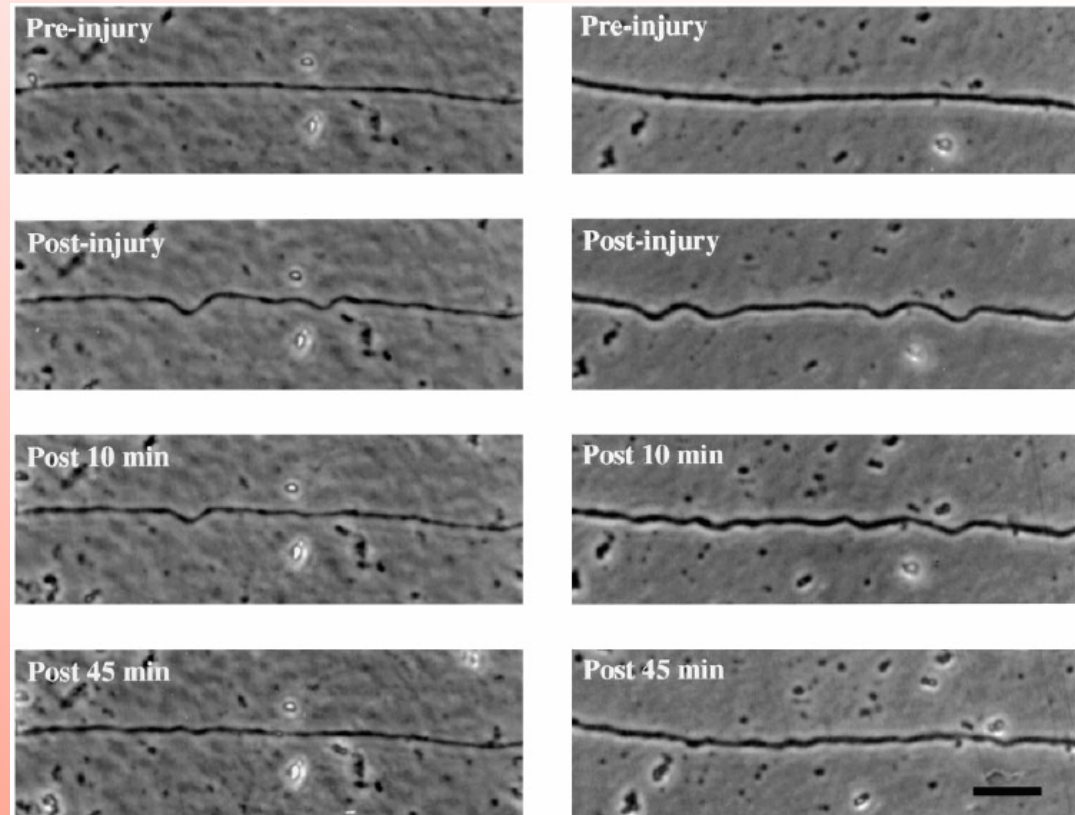
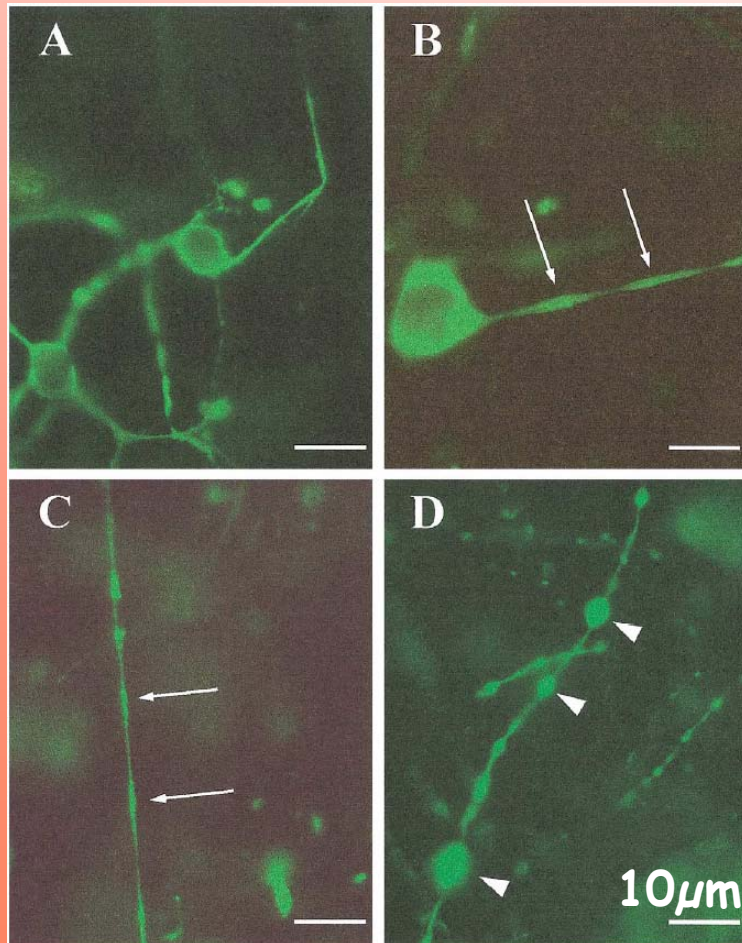


Distintos motores moleculares



microtubulos

Algunas consecuencias de las enfermedades



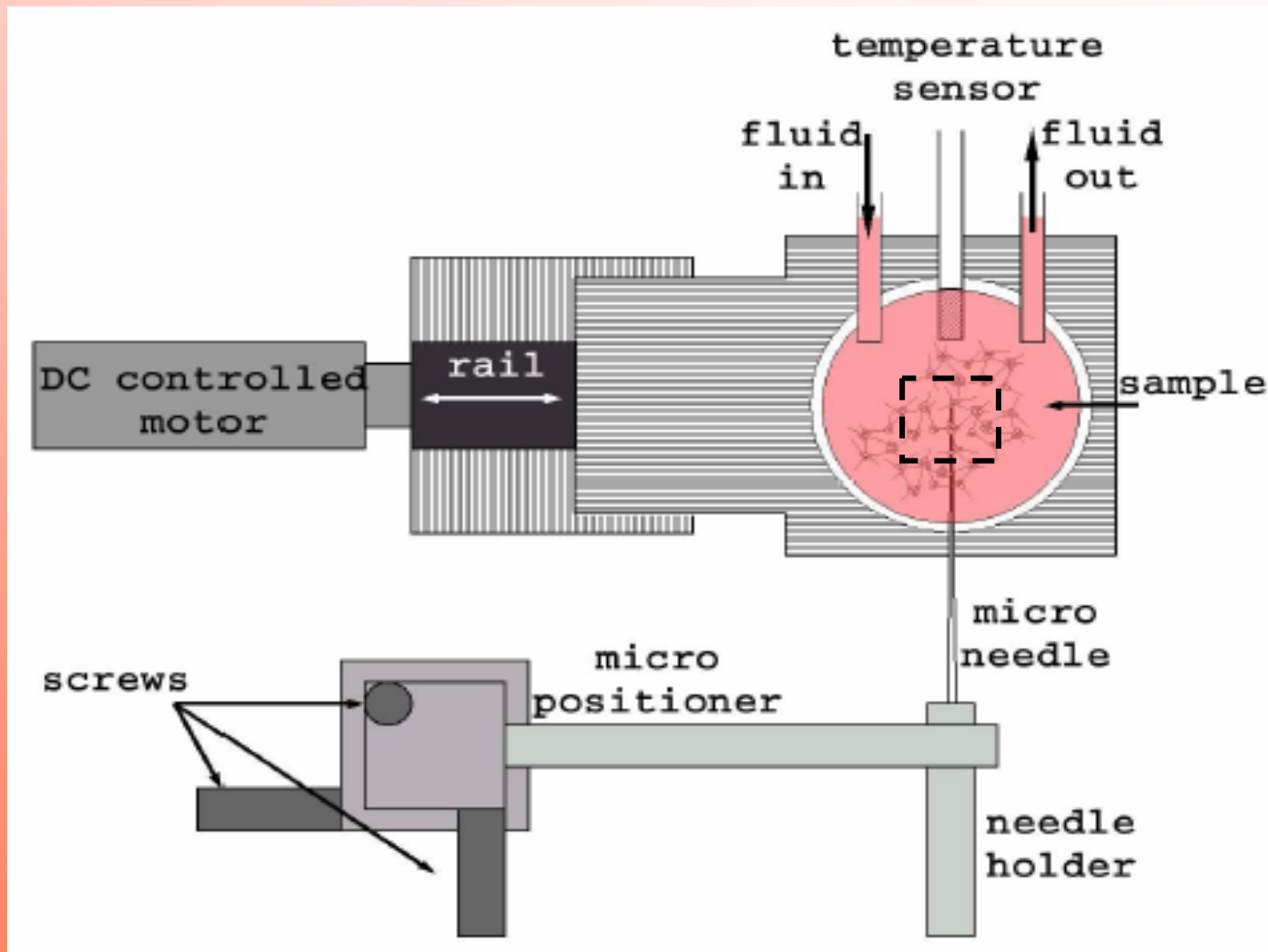
*B. Roediger, P.J. Armati /
Neurobiology of Disease 13 (2003)
222–229*

*Smith et al.
J. Neurosci., June 1, 1999, 19(11):4263–4269*

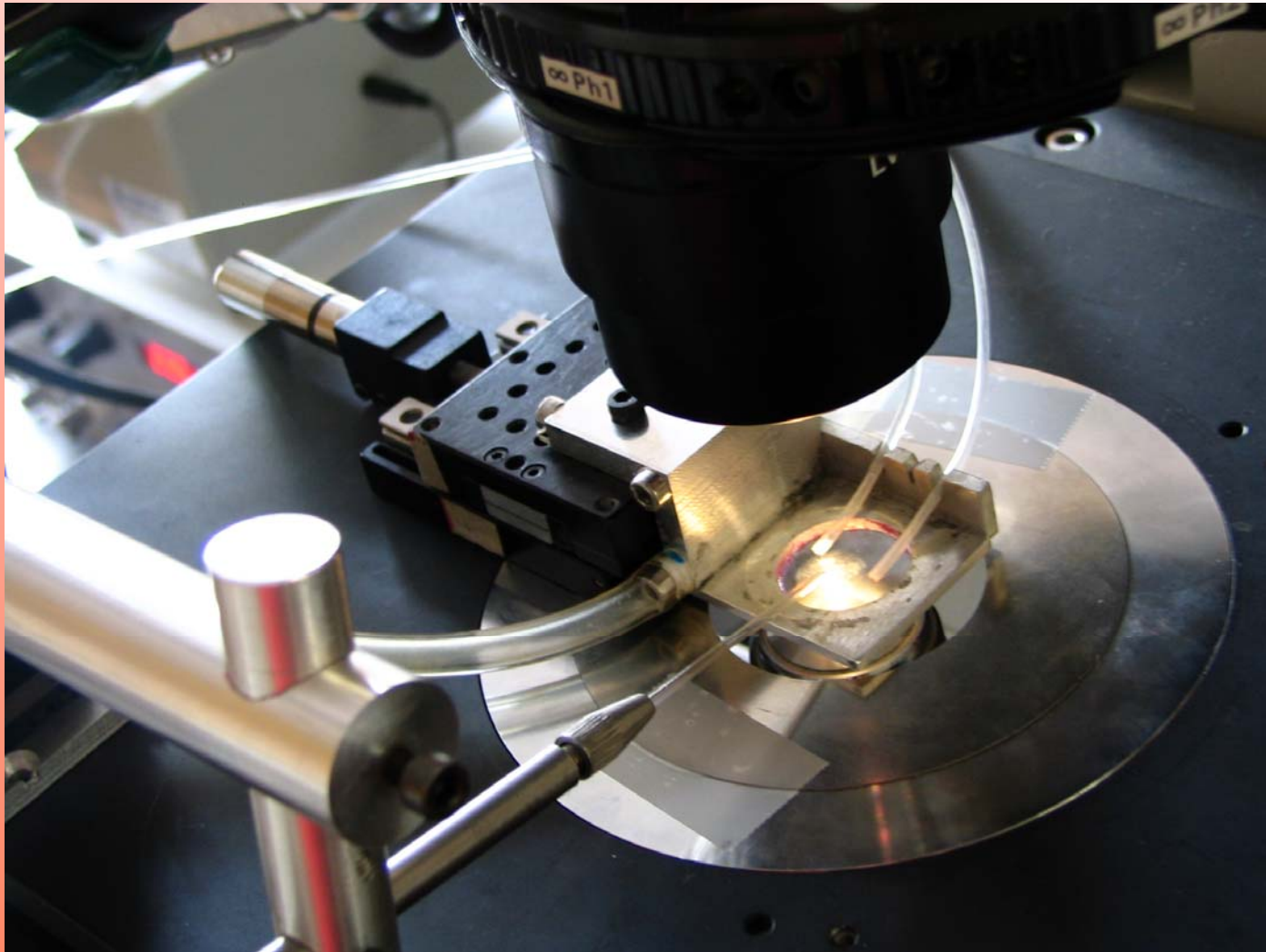
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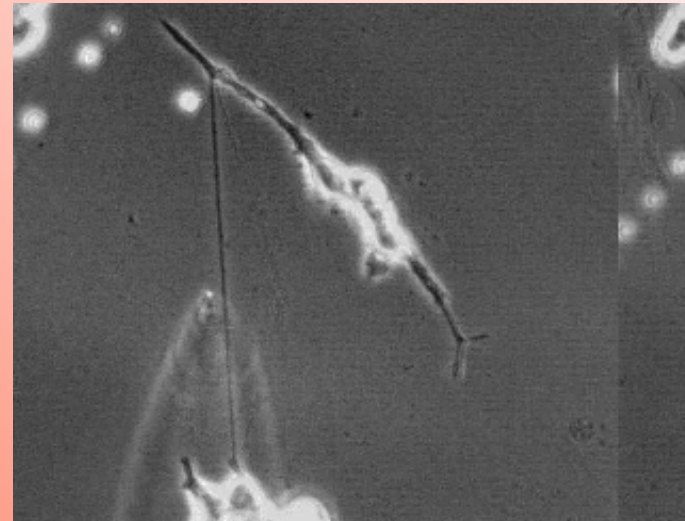
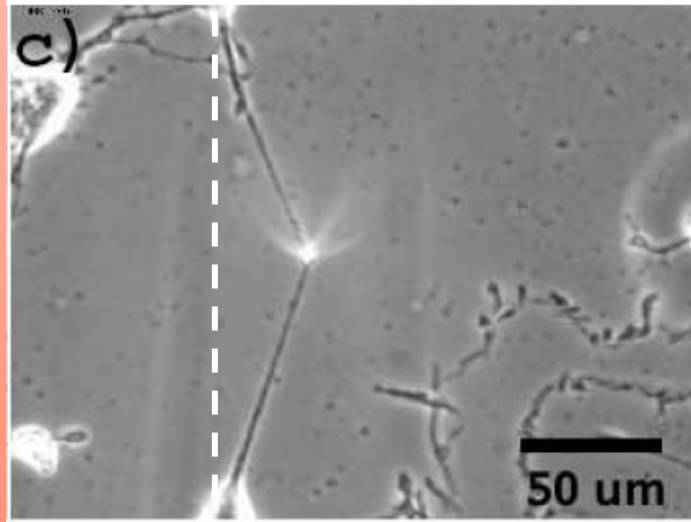
El dispositivo experimental



El dispositivo experimental



¿Cómo estiramos la neurita?



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Tres regímenes observados

elástico

visco-elástico

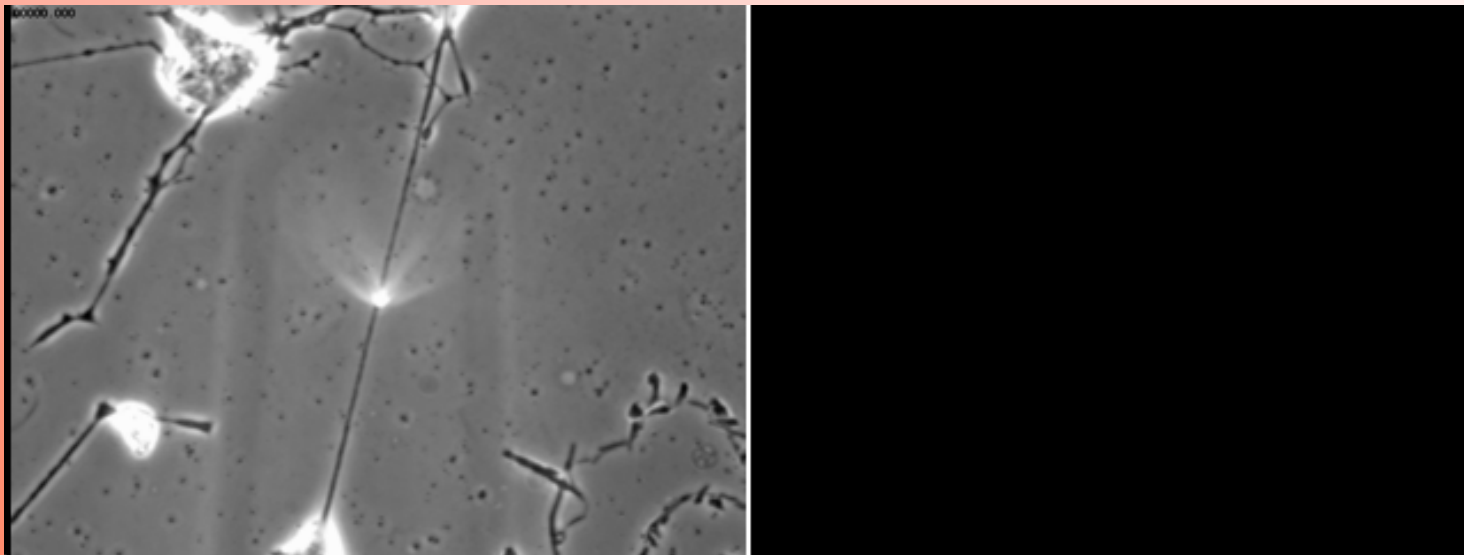
'activo'

$\tau \sim 1s$

$\tau \sim 10s$

$\tau \sim 400s$

τ



elástico

$\tau \sim 1s$

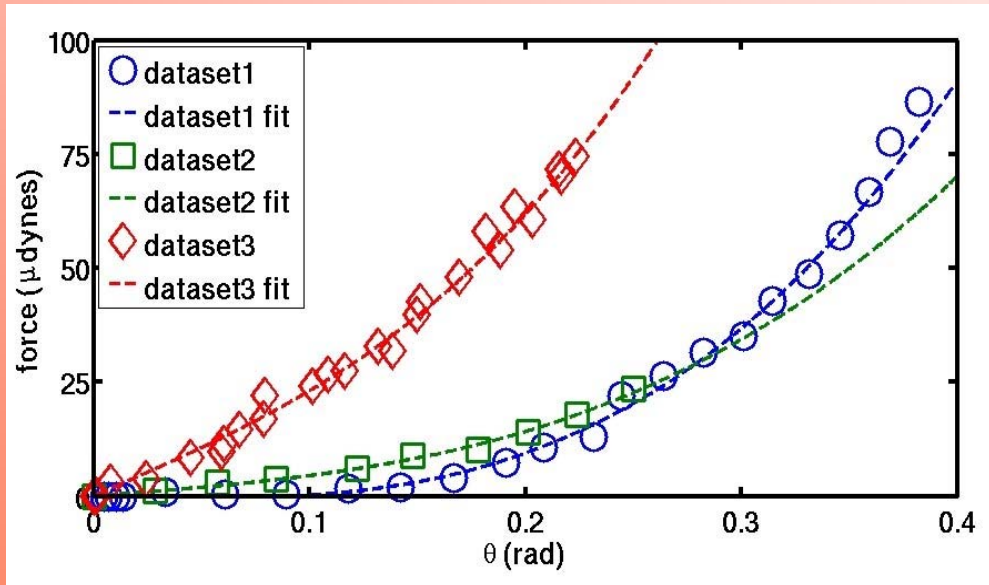
visco-elástico

$\tau \sim 10s$

'activo'

$\tau \sim 400s$

τ



$$F_{needle} = \kappa \frac{L_x}{2} \theta^3 + 2T_o \theta.$$

elástico

visco-elástico

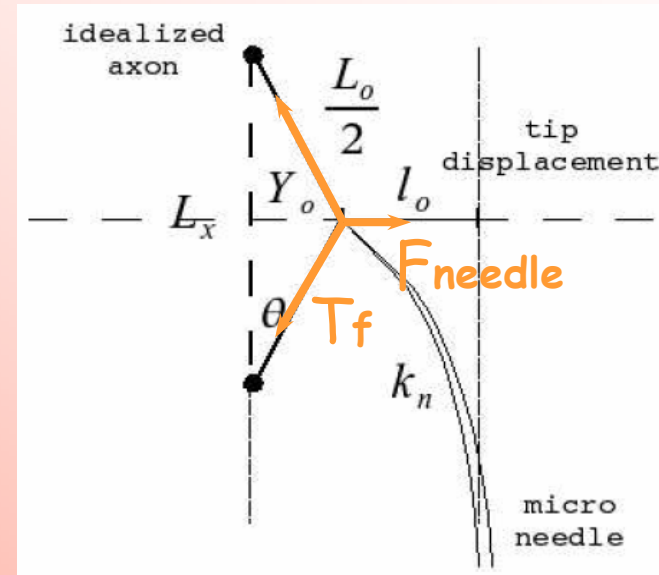
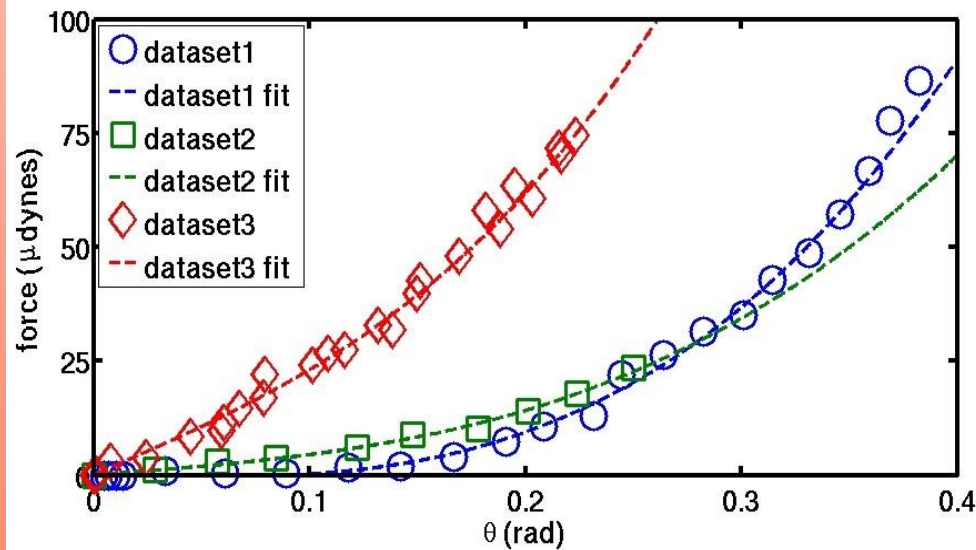
'activo'

$\tau \sim 1s$

$\tau \sim 10s$

$\tau \sim 400s$

τ



$$F_{needle} = \kappa \frac{L_x}{2} \theta^3 + 2T_o \theta.$$

Hyp: Ley de Hooke (a) y $\theta \ll 1$

$$F_{needle} = 2 \left[\kappa \delta_\kappa + T_o \right] \sin \theta. \quad (a)$$

$$\delta_\kappa = \frac{L_o - L_x}{2} = \frac{L_o}{2} (1 - \cos \theta)$$

elástico

visco-elástico

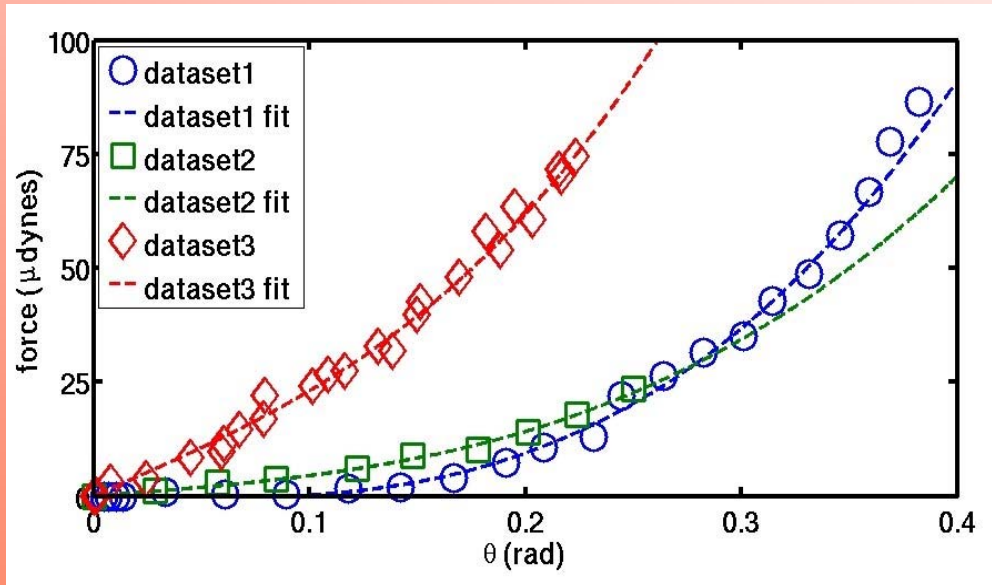
'activo'

$\tau \sim 1s$

$\tau \sim 10s$

$\tau \sim 400s$

τ



$$F_{needle} = \kappa \frac{L_x}{2} \theta^3 + 2T_o \theta.$$



T_o, κ deducidos del fit

Tres regímenes observados

elástico

visco- elástico

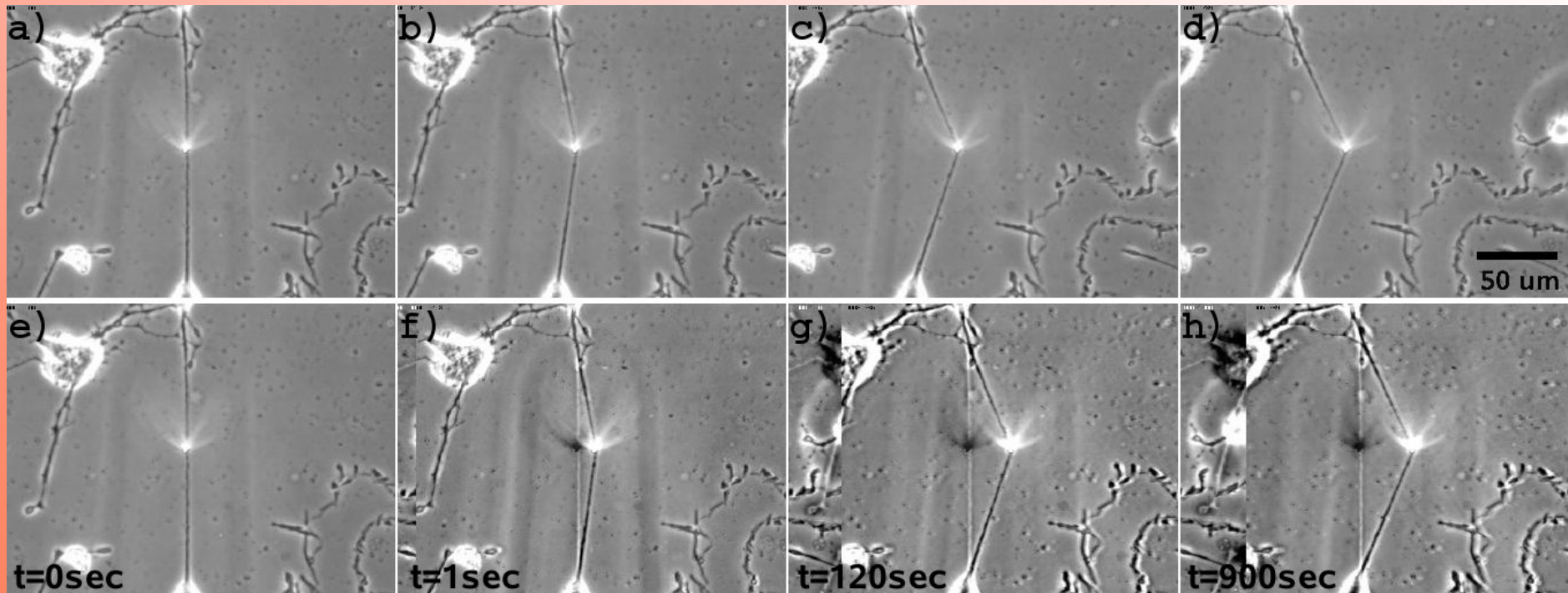
'activo'

$\tau \sim 1s$

$\tau \sim 10s$

$\tau \sim 400s$

τ



desplazamiento impuesto

relajación

elástico

visco- elástico

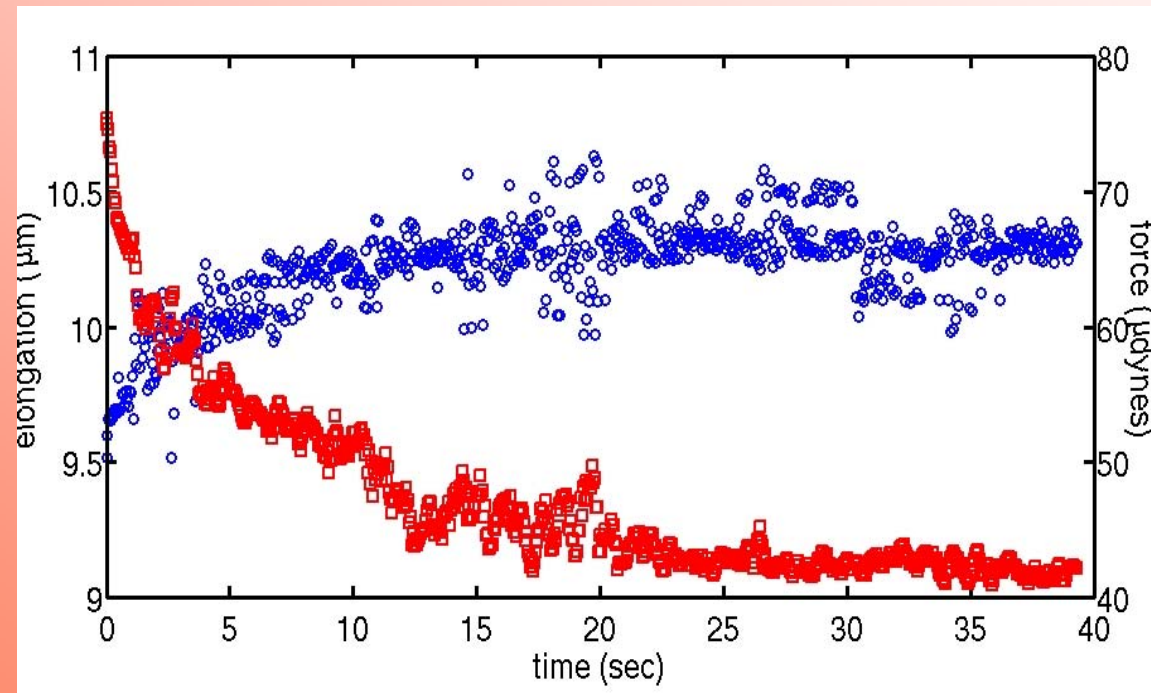
'activo'

$\tau \sim 1s$

$\tau \sim 10s$

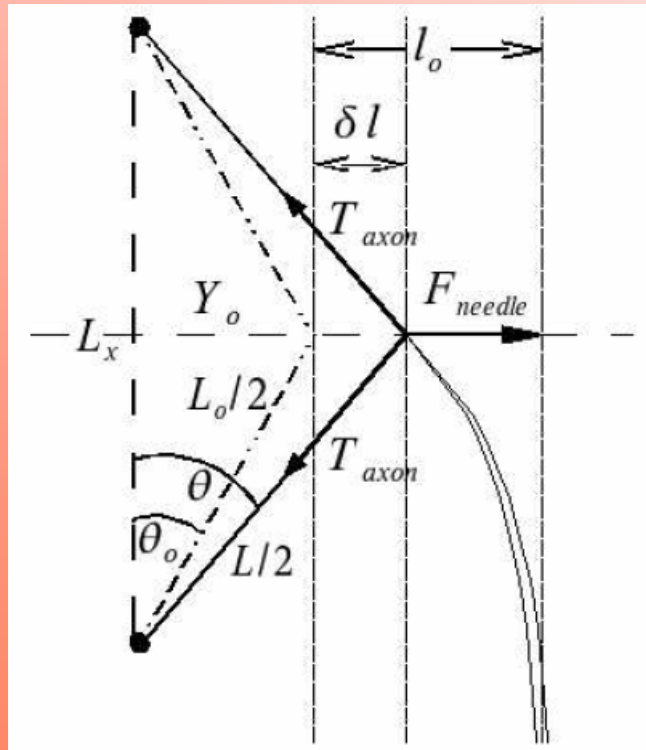
$\tau \sim 400s$

τ

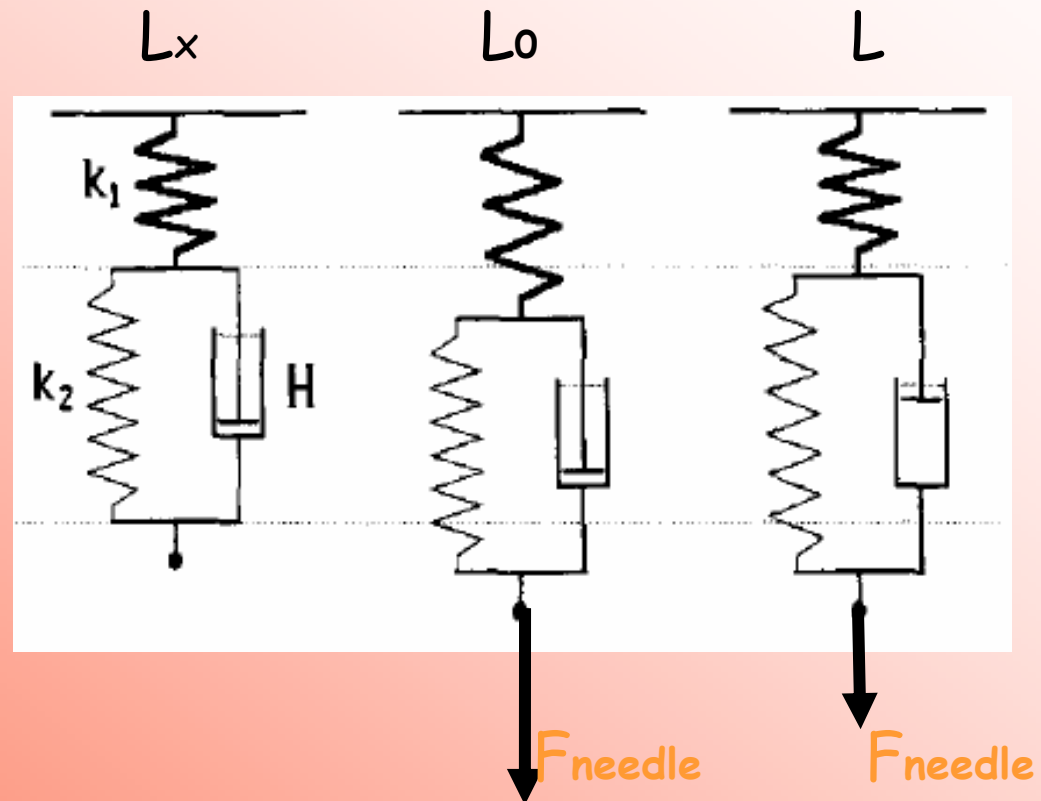


Modelo de la respuesta de las neuritas

Componente visco-elástica



modelo Dennerll(*)



(*) TJ Dennerll *et al.*, J. Cell Biology, 109, 1989

Tres regímenes observados

elástico

visco-elástico

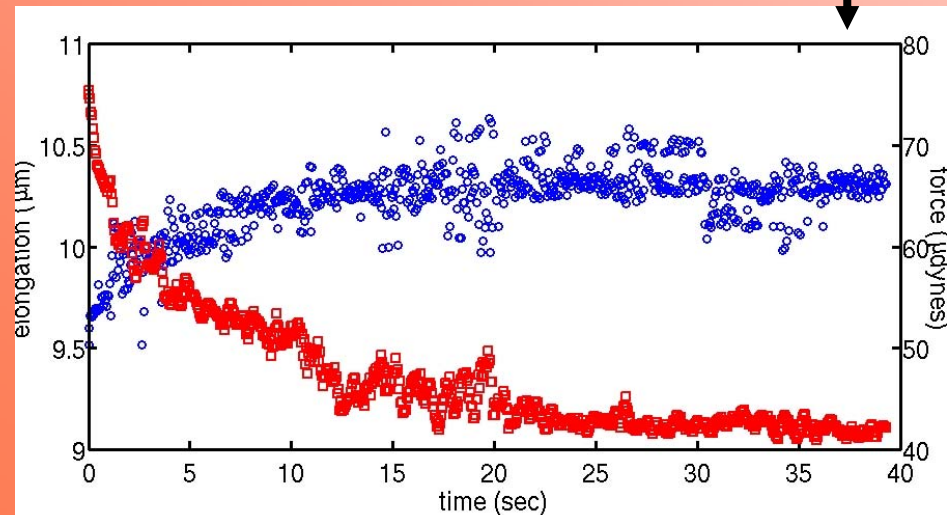
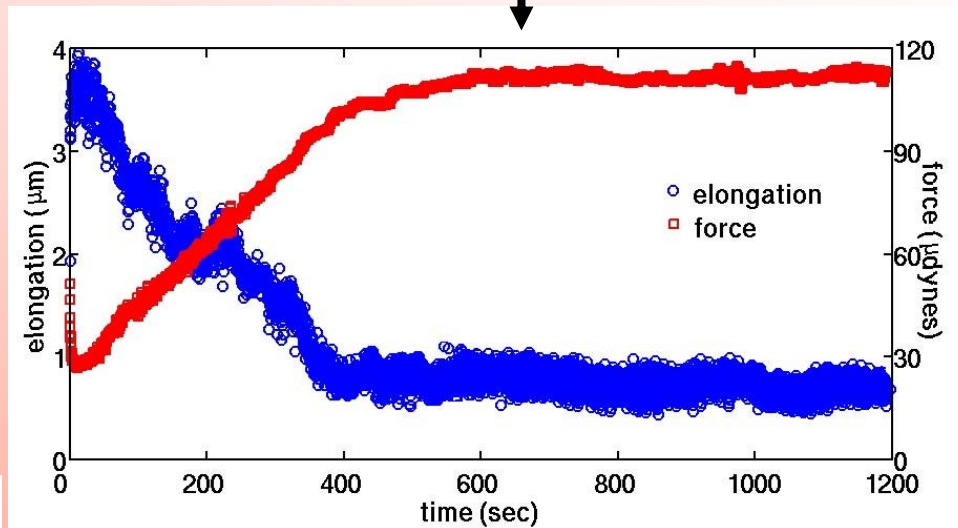
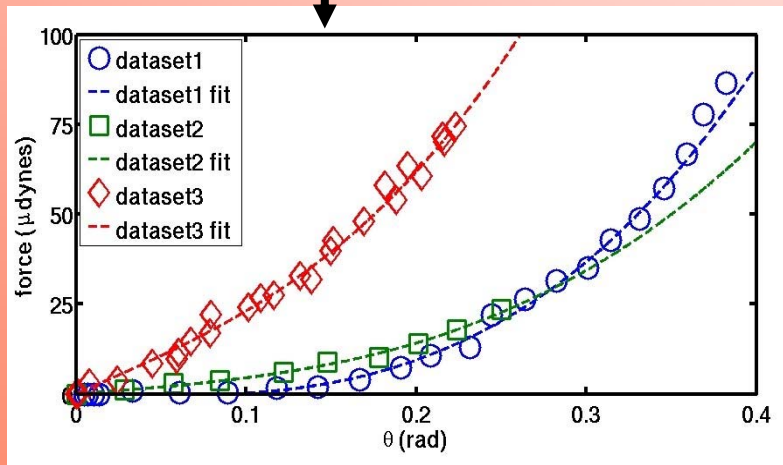
'activo'

$\tau \sim 1s$

$\tau \sim 10s$

$\tau \sim 400s$

τ

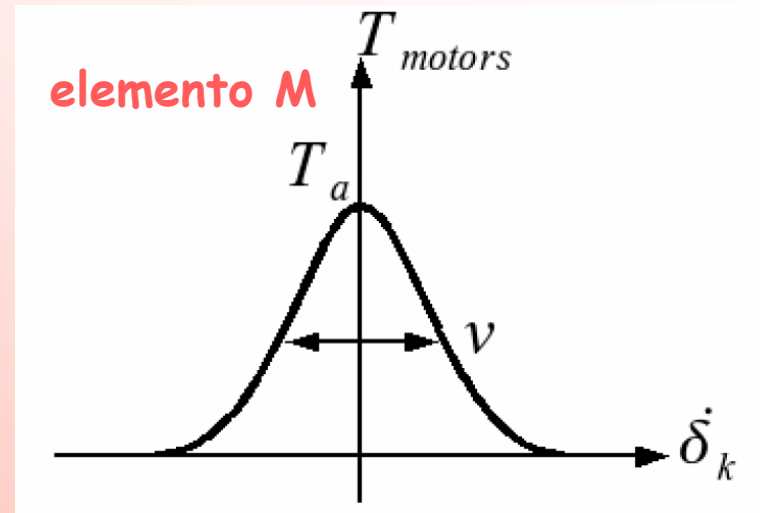
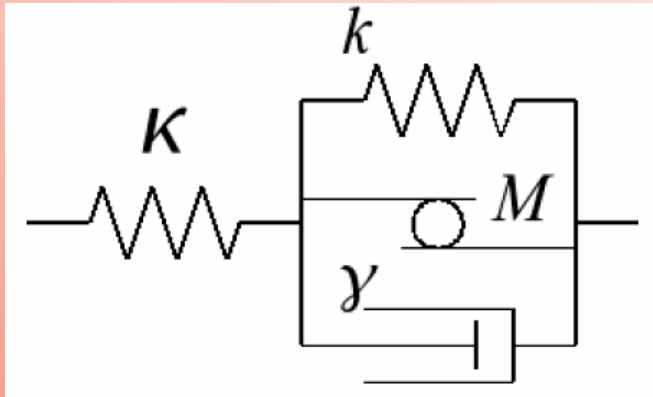


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Modelo de la respuesta de las neuritas (Melo-Bernal)

Componente 'activa'



$$2(\kappa\delta_\kappa + T_o) \sin \theta = k_n(l_o - \delta l)$$

$$k\delta_k + \gamma\dot{\delta}_k + T_a e^{-\dot{\delta}_k^2/v^2} = \kappa\delta_\kappa + T_o$$

$$2(\delta_\kappa + \delta_k) = \Delta L + 2\delta_\kappa^o.$$

Poniendo

$$\alpha = \sin \theta_o$$

$$\beta = (\alpha + k_n/2\alpha\kappa)$$

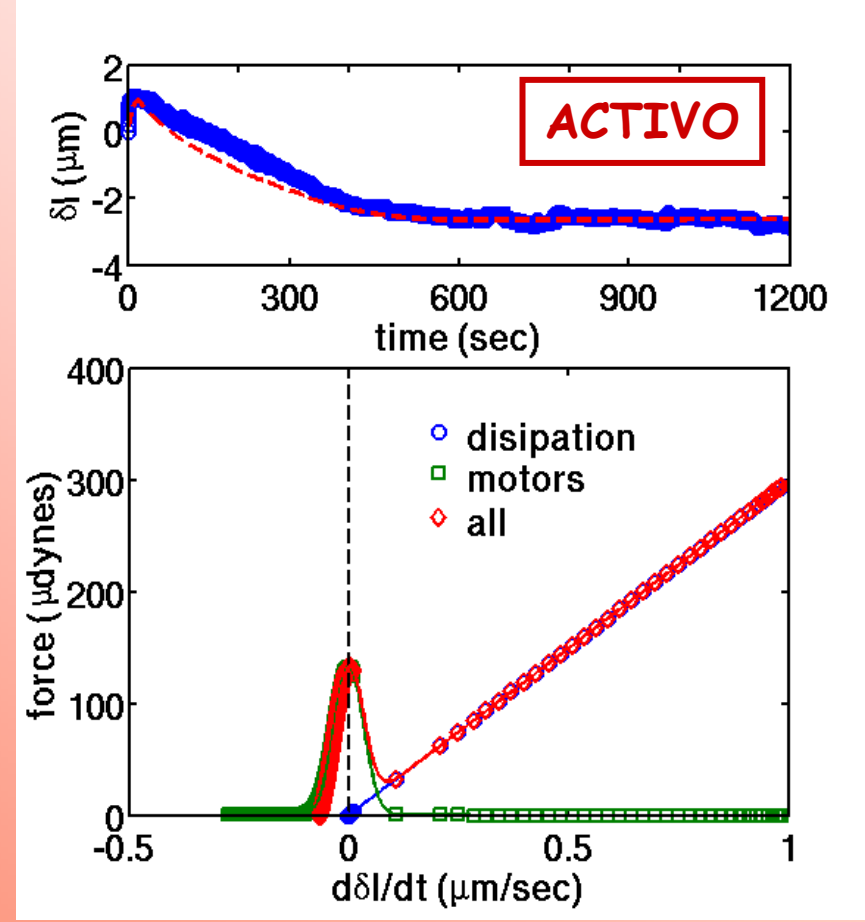
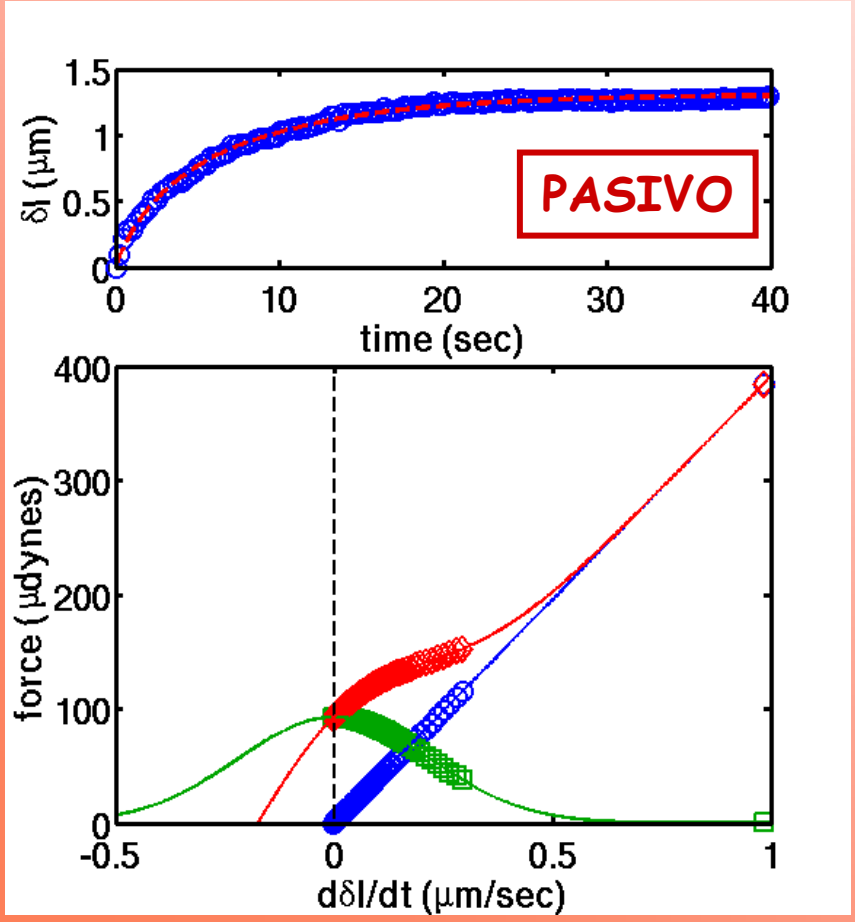
$$\boxed{\beta\gamma\dot{\delta}l} + \boxed{T_a e^{-\beta^2\dot{\delta}l^2/v^2}} + k \left(\beta + \frac{k_n}{2\alpha k} \right) \delta l = \frac{k_n}{2\alpha} l_o$$

disipación motores

Ajuste a 4 parametros (γ , T_a , v , k) de datos experimentales

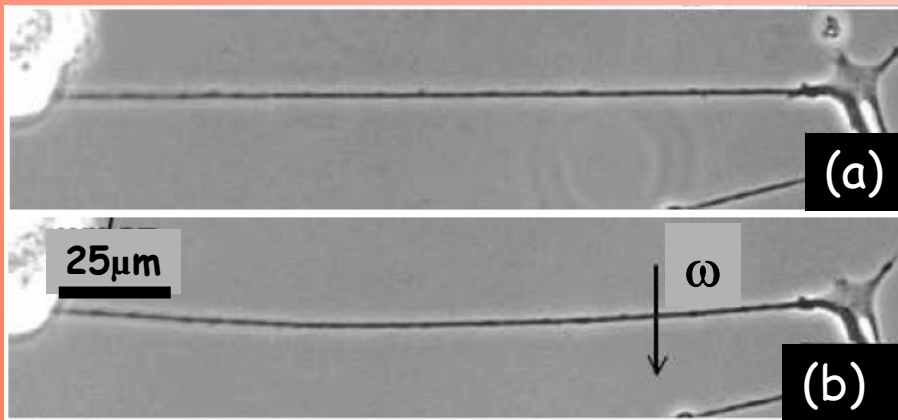
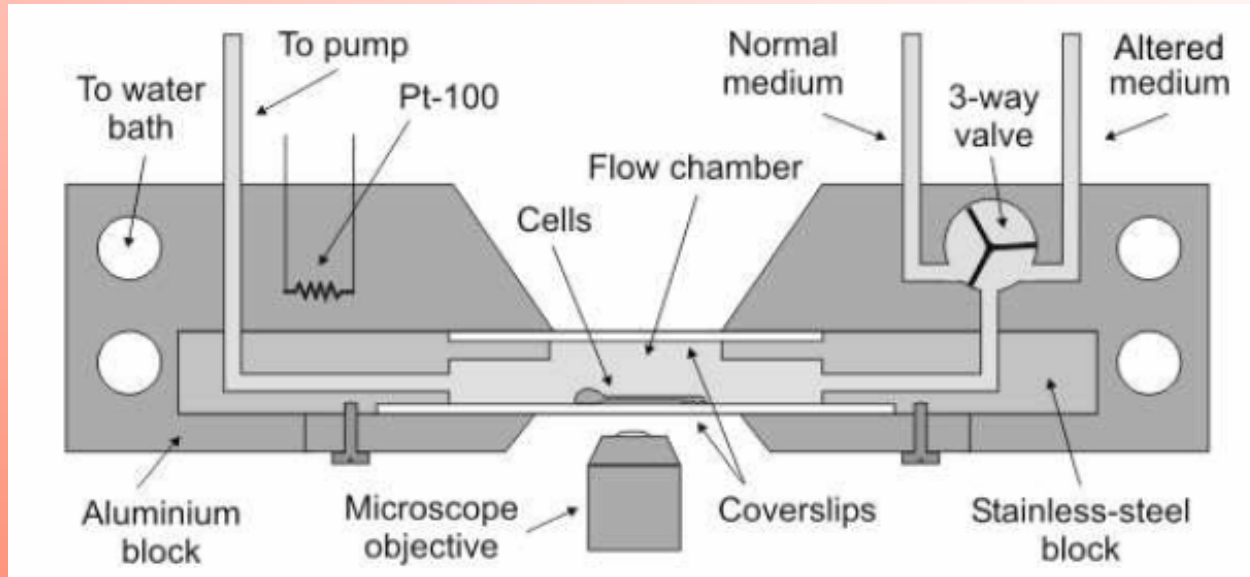
$$\boxed{\beta\gamma\dot{l}} + \boxed{T_a e^{-\beta^2\dot{l}^2/v^2}} + k \left(\beta + \frac{k_n}{2\alpha k} \right) \delta l = \frac{k_n}{2\alpha} l_o$$

disipación motores



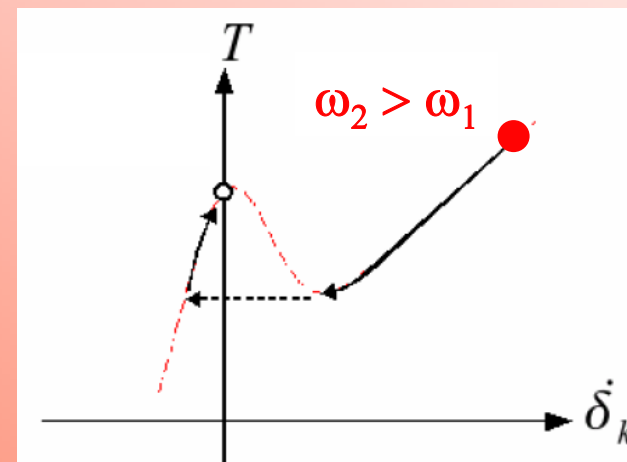
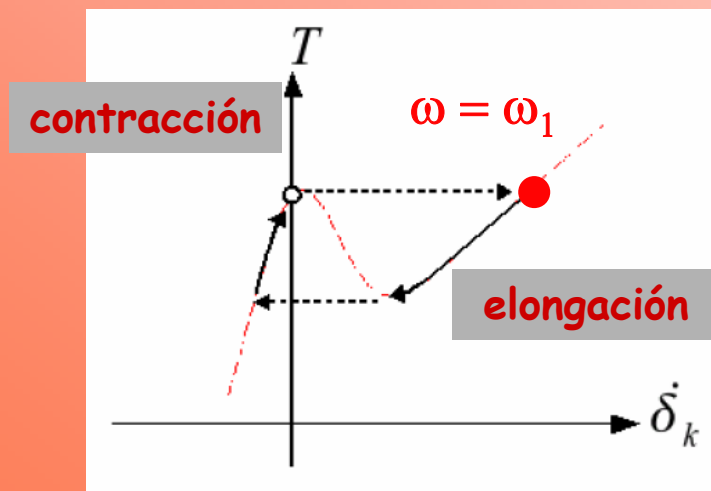
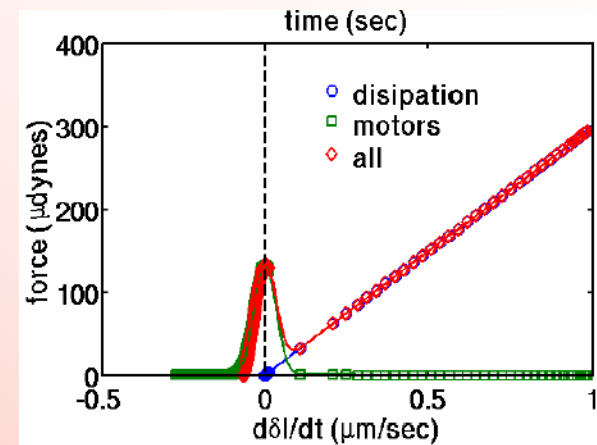
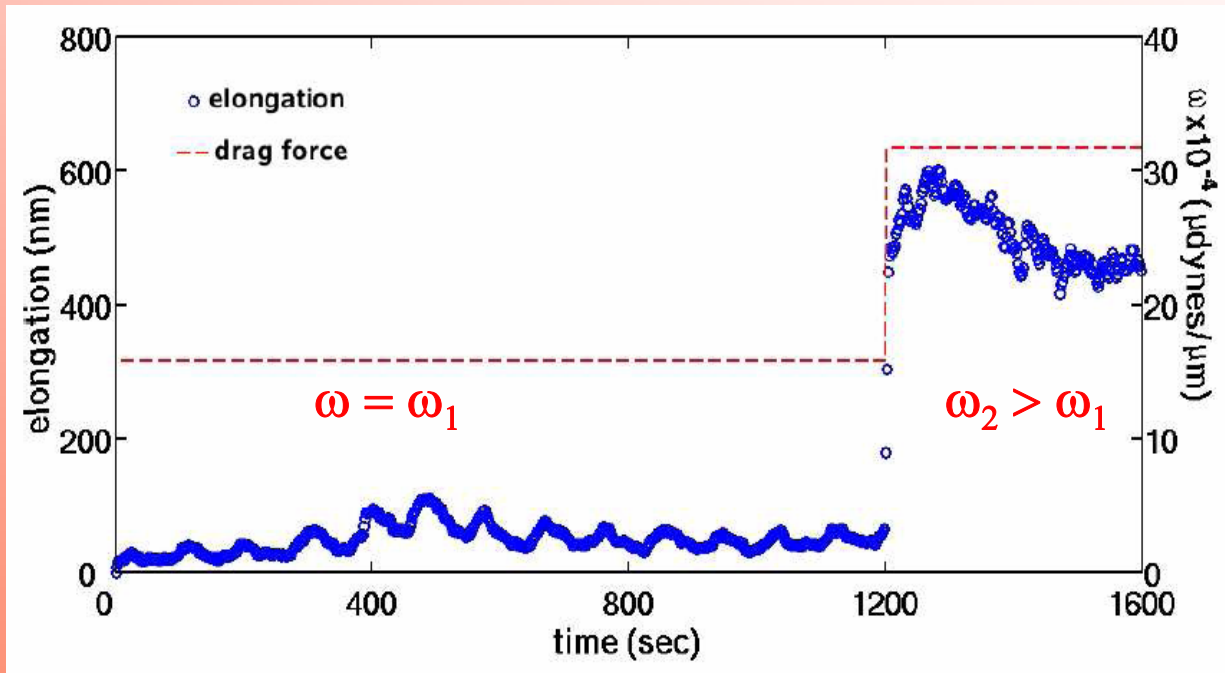
Experimentos adicionales (Bayreuth, Alemania)

dispositivo experimental

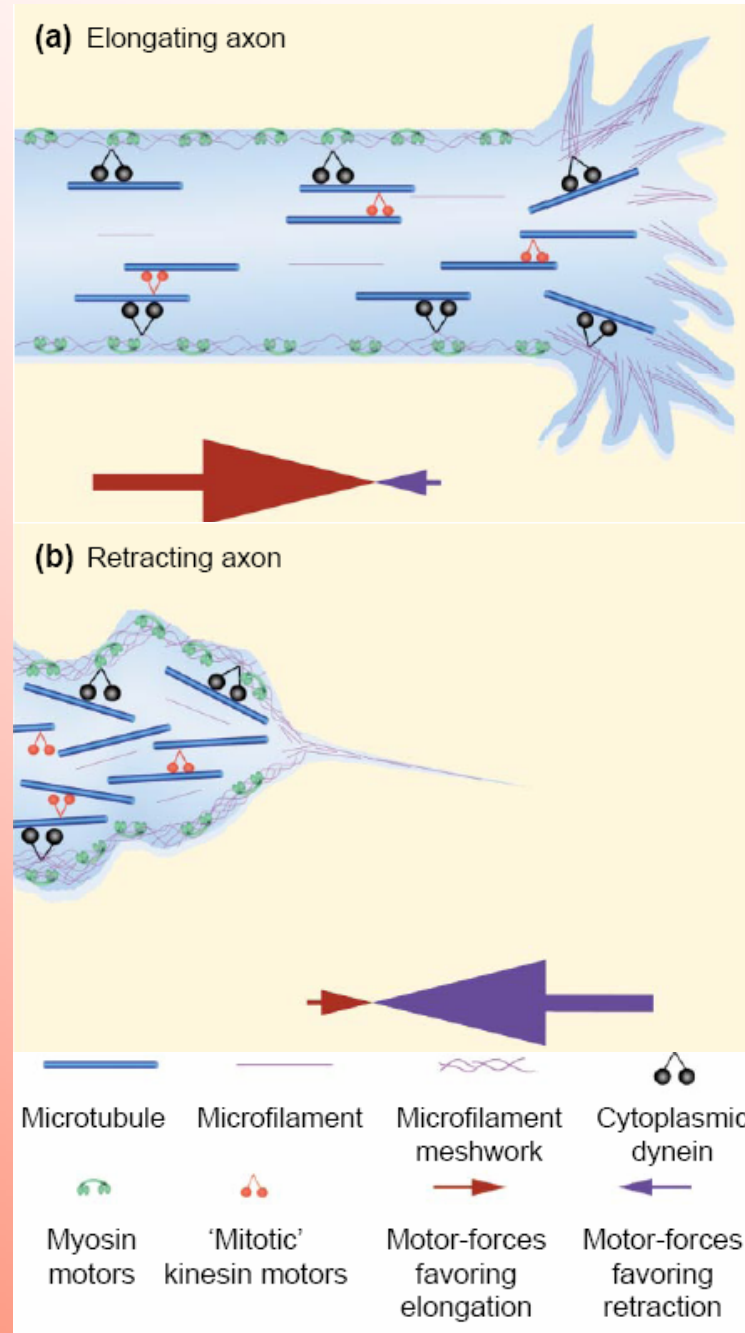
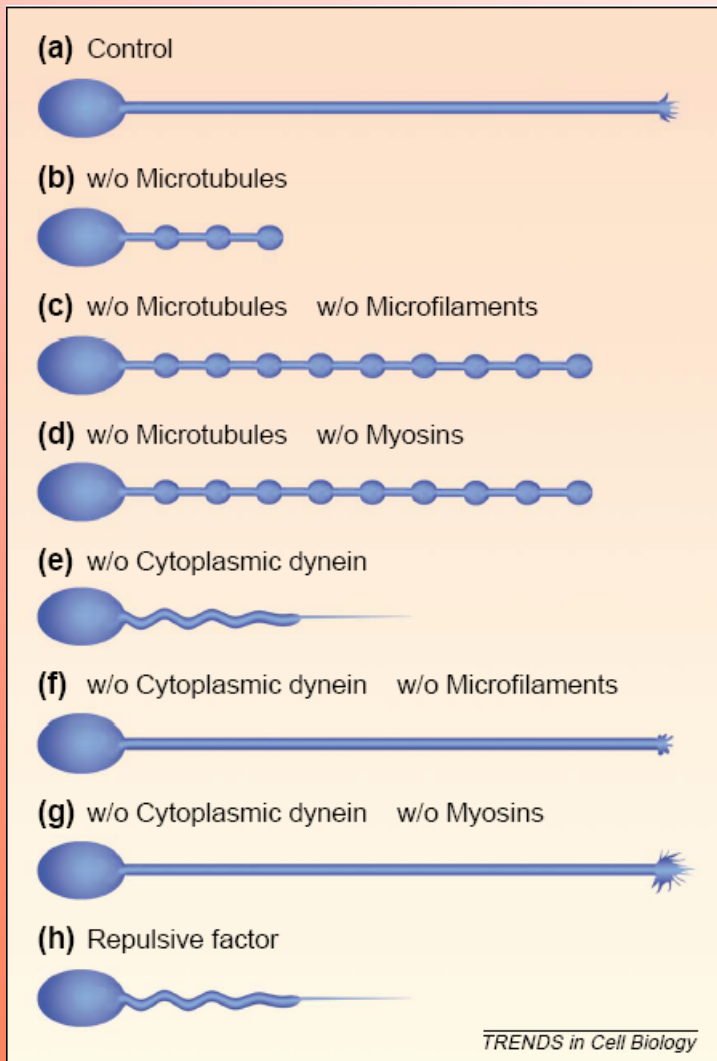


‘cuerda’ bajo gravedad

Oscilaciones controlables del largo de la neurita

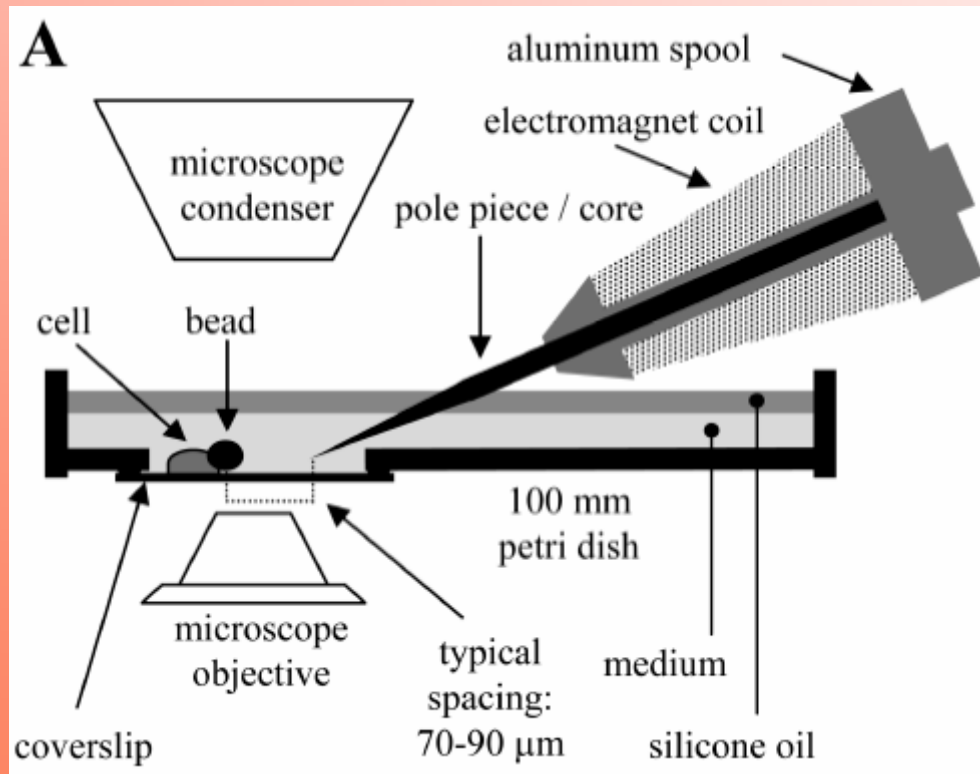


Validez biológica del modelo

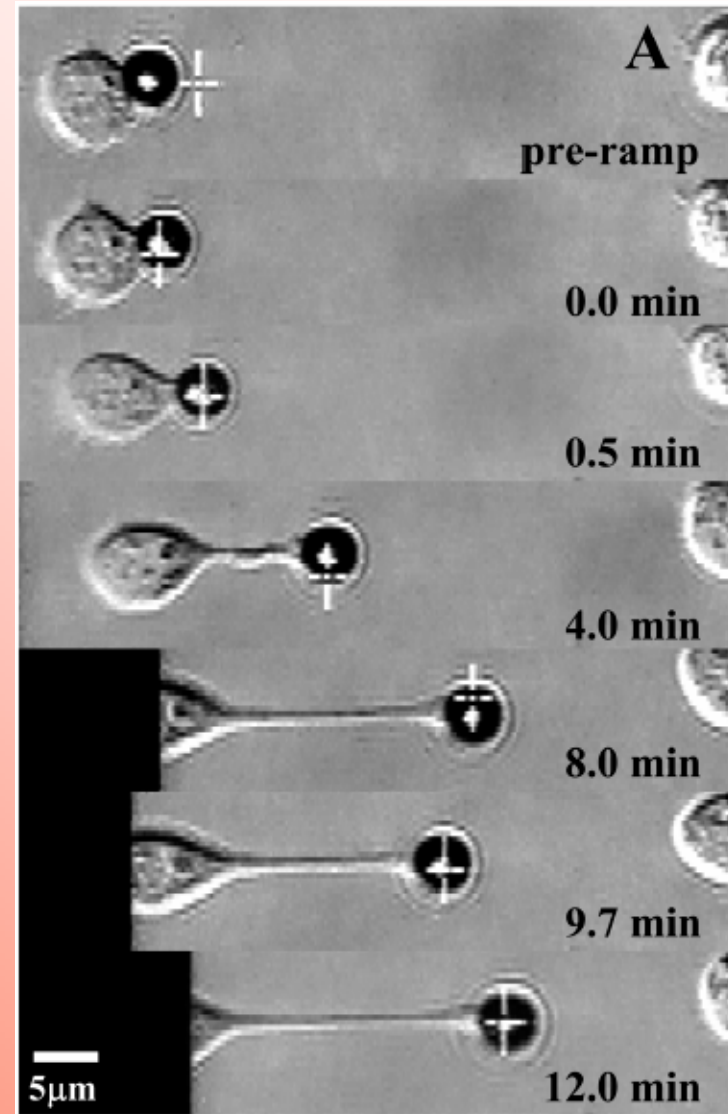


Baas&Ahmad
TRENDS in Cell Biology
Vol.11 No.6 , 2001

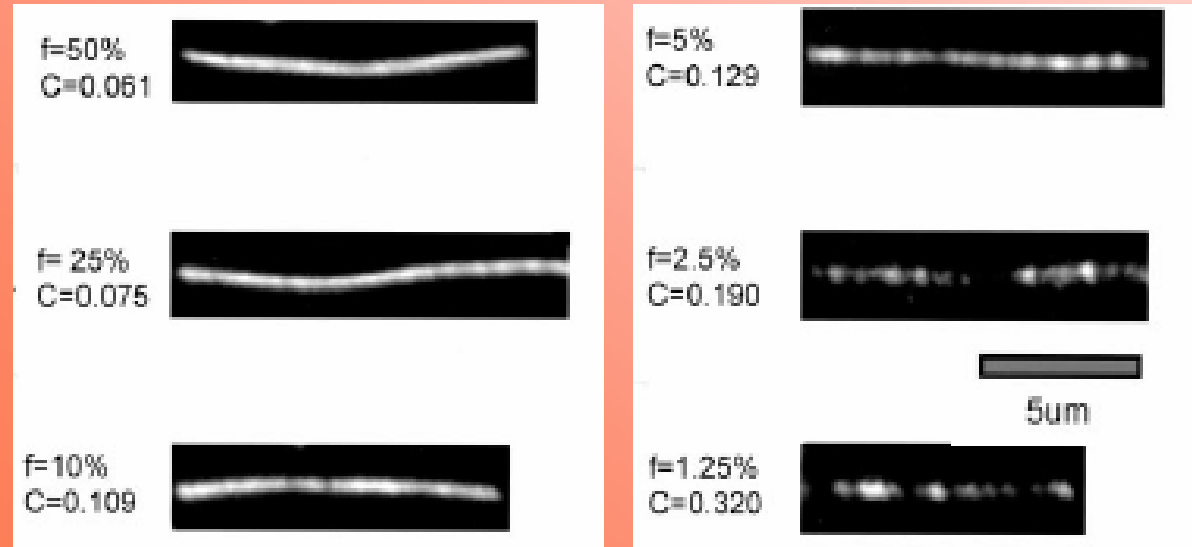
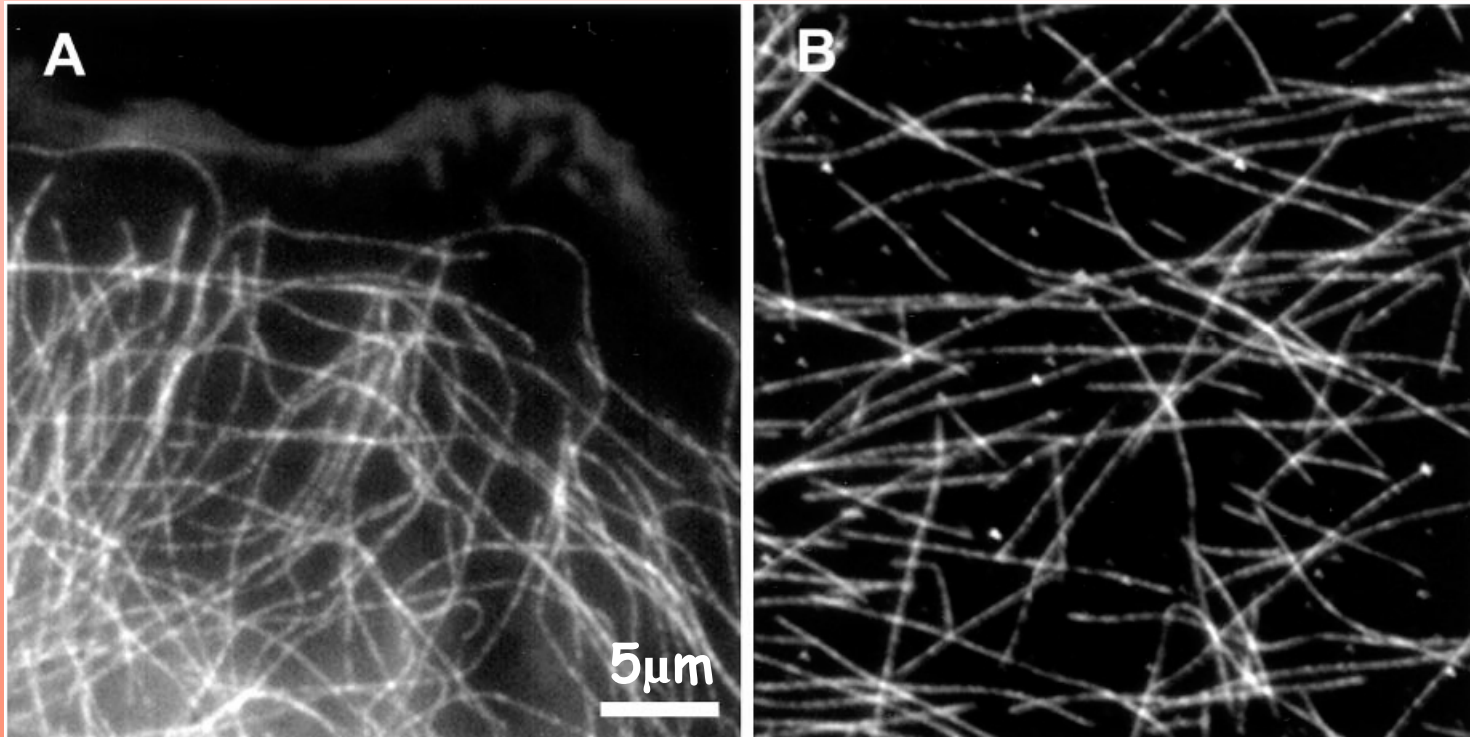
Perspectivas: mejorar el dispositivo



Fass&Odde
Biophysical Journal 85(1)
623-636, 2003



Perspectivas: desarrollar otras herramientas



*Waterman-Storer & Salmon
Biophysical Journal 75(1)
2059-2069, 1998*

Conclusiones

- Sistema interesante para las dos comunidades
- Modelo reproduciendo el abanico completo de las situaciones experimentales

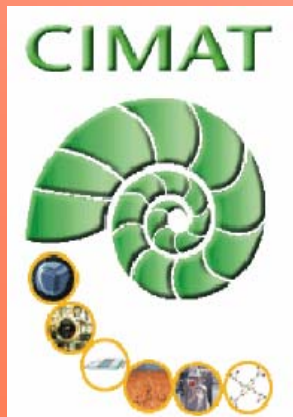
Agradecimientos

A Nicolas Mujica por su invitación y a todos por su presencia...



Lab. de Física no lineal,
USACH

Francisco Melo
Roberto Bernal
... y todos los demás!



Fernando Lund