

¿Cómo plegar un cerebro?

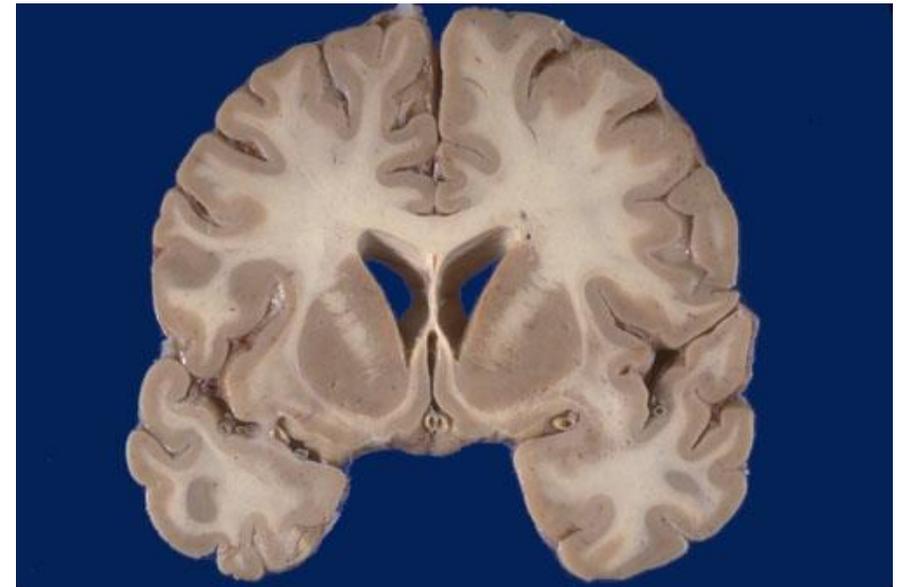
Marcos Meo



- “Cortical folding scales universally with surface area and thickness, not number of neurons” Bruno Mota, Suzana Herculano-Houzel
- “Gyrification from constrained cortical expansion” Tuomas Tallinen

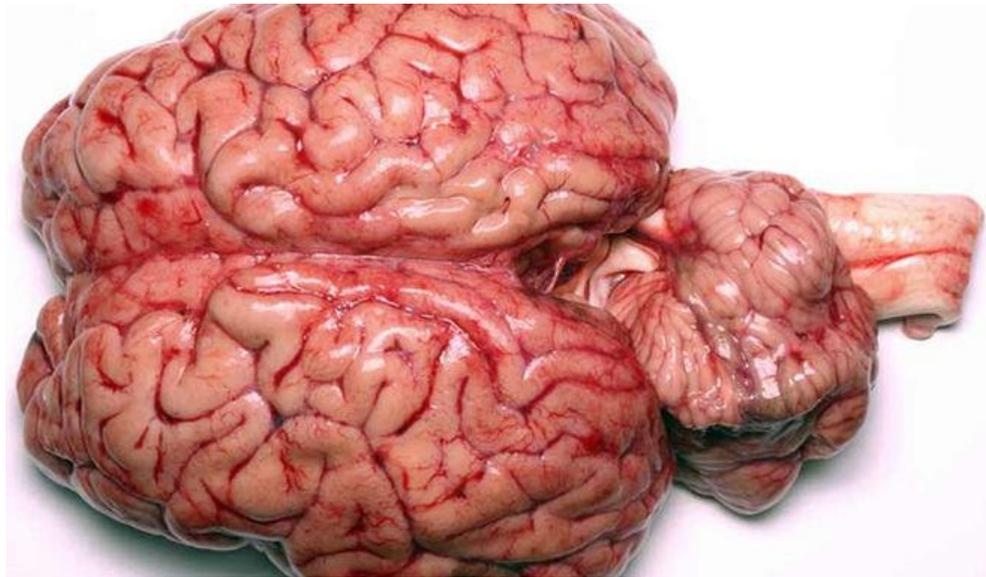
El Cerebro

- Volumen: 1200 cm³
- Área superficial: 2000-2500 cm²
- Espesor: 2-4 mm
- 100 mil millones neuronas
- 20 mil millones corticales
- 7000 conexiones cada una
- $0,15 \times 10^{15}$ conexiones
- Más de 150.000 km de fibra nerviosa



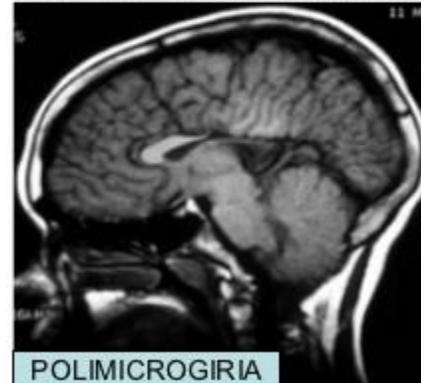
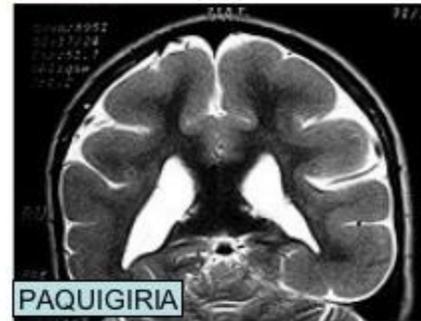
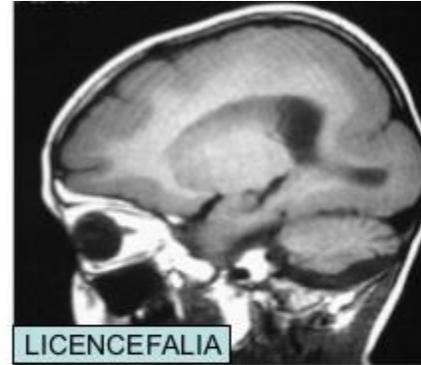
Gyrification

- Proceso de plegamiento de la corteza cerebral que da origen a la formación de circunvoluciones y surcos.



Malformaciones

- Lisencefalia
- Paquigiria
- Polimicrogiria



- Ley de potencia  superficie auto-similar
- Mecanismo universal responsable del plegamiento cortical

$$d = 2,484 \pm 0,036$$

$$d \simeq d_{papel} = 2,5$$

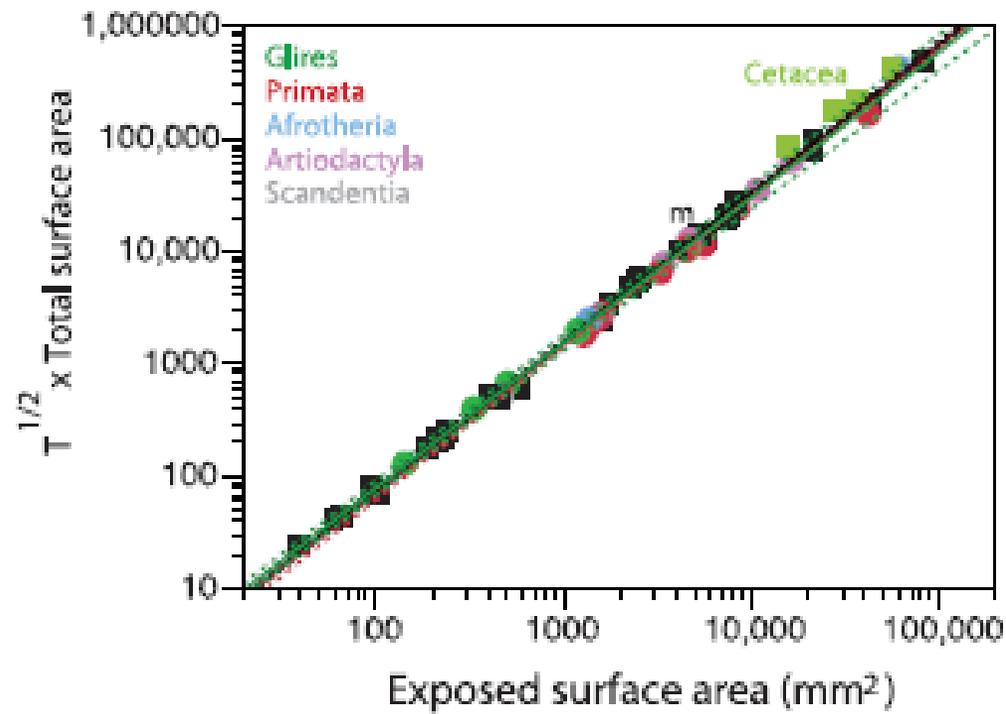
$$E_V = pV$$

$$E_S(\vec{s}, n) = \int d\vec{x}_1 d\vec{x}_2 \delta(\vec{s}(\vec{x}_1) - \vec{s}(\vec{x}_2)) \Lambda_T(n(\vec{x}_1) - n(\vec{x}_2))$$

$$\Lambda_T(u) = \begin{cases} T - 2|u| & -\frac{T}{2} \leq u \leq \frac{T}{2} \\ 0 & \text{otherwise} \end{cases}$$

$$E = E_V + E_S$$

$$\sqrt{T} A_G = k A_E^{1,25} \quad k \propto p$$



$$\sqrt{T} A_G = k A_E^{1,305 \pm 0,010}$$

$$r^2 = 0,998$$

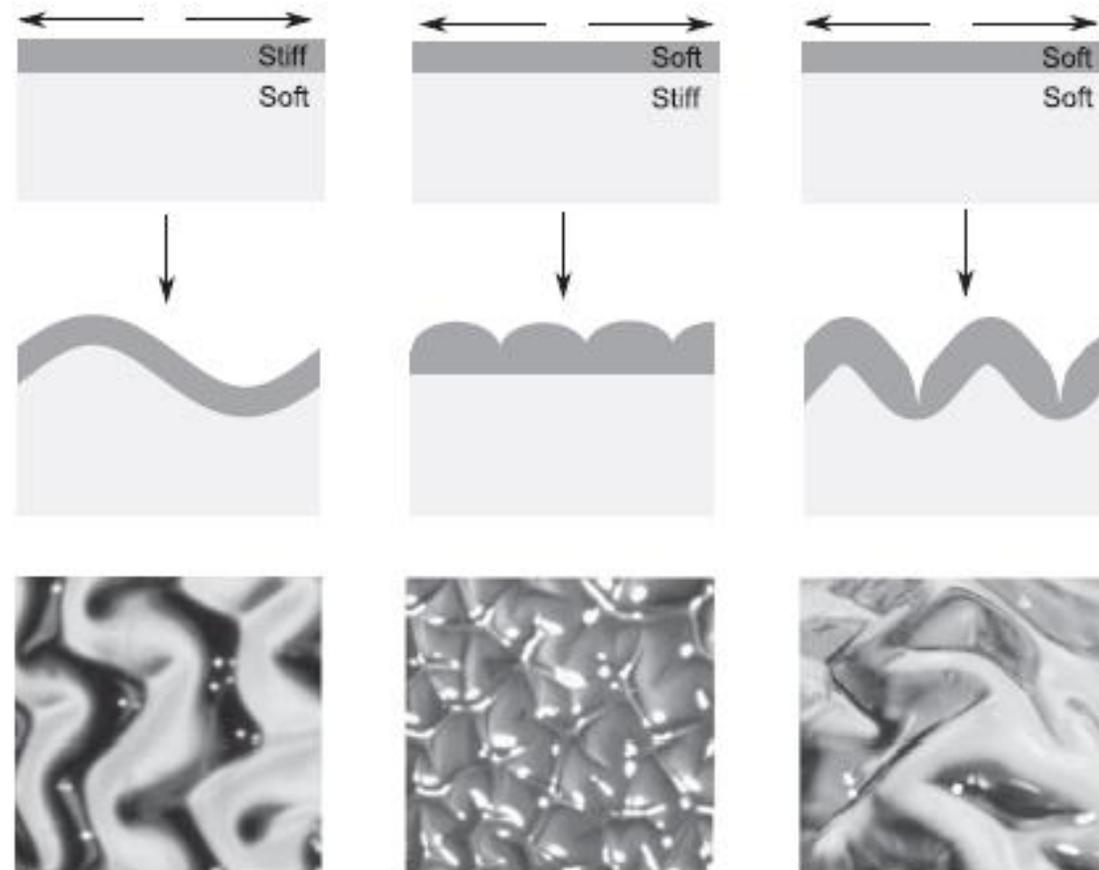


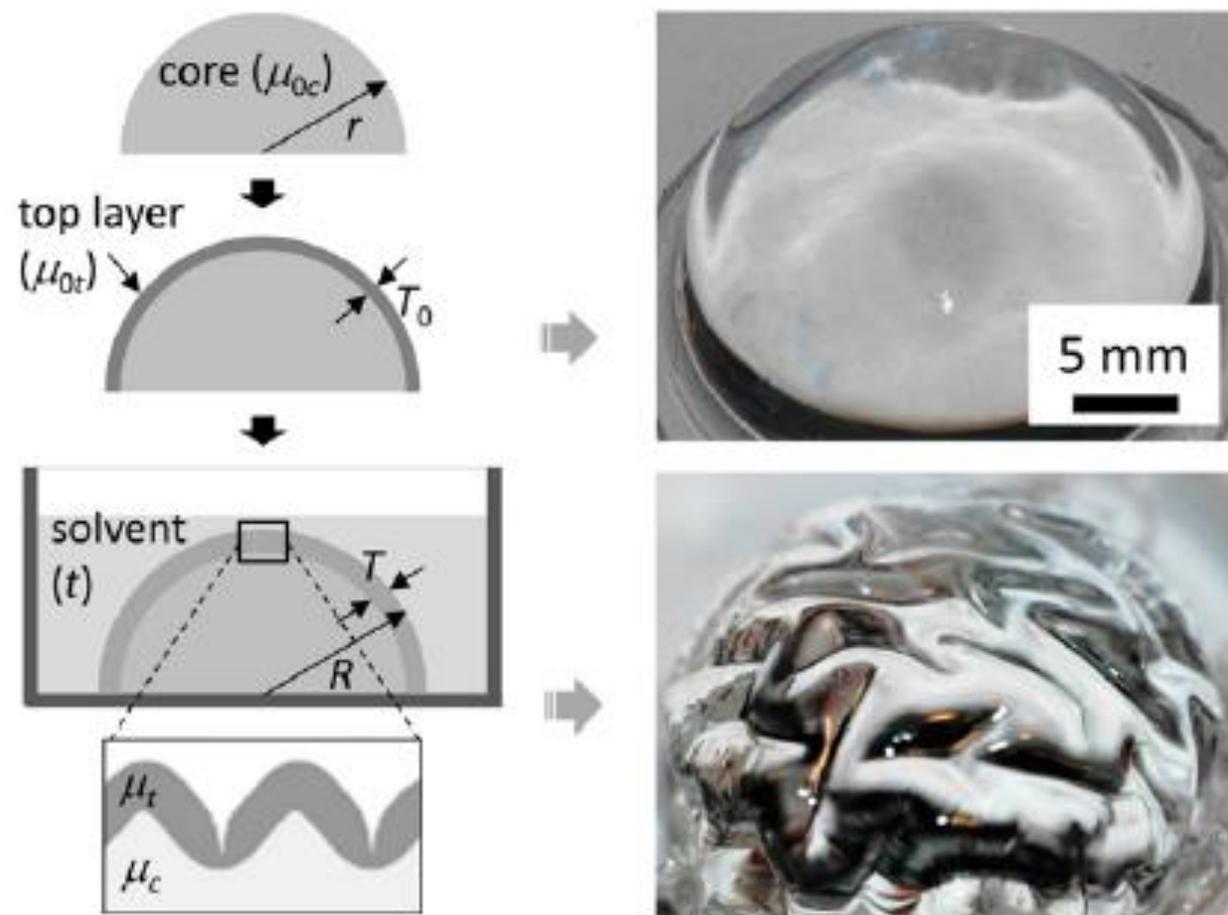
“Gyrification from constrained cortical expansion”

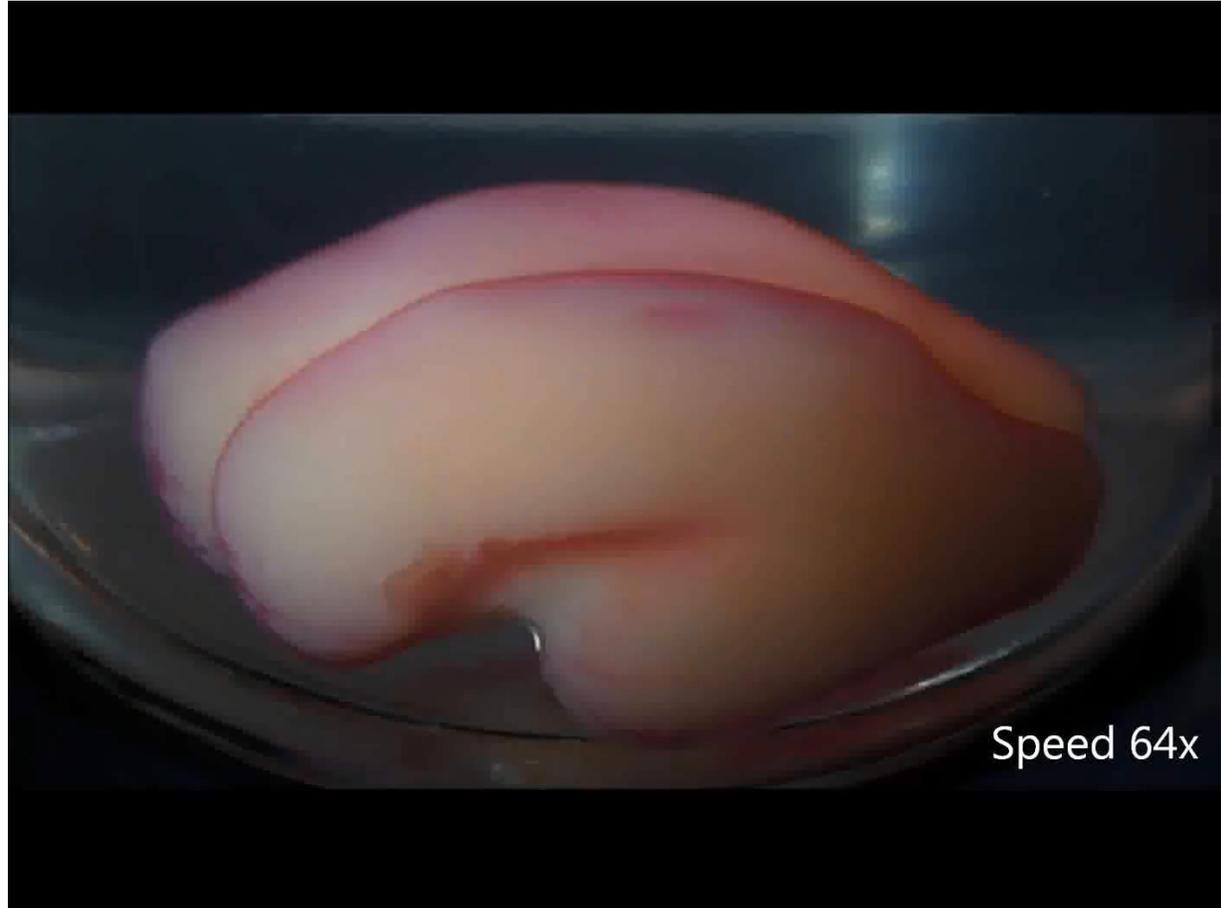
Hipótesis:

- Morfogénesis química
- Tensiones producidas por los axones

- Crecimiento de la corteza relativo a capas inferiores







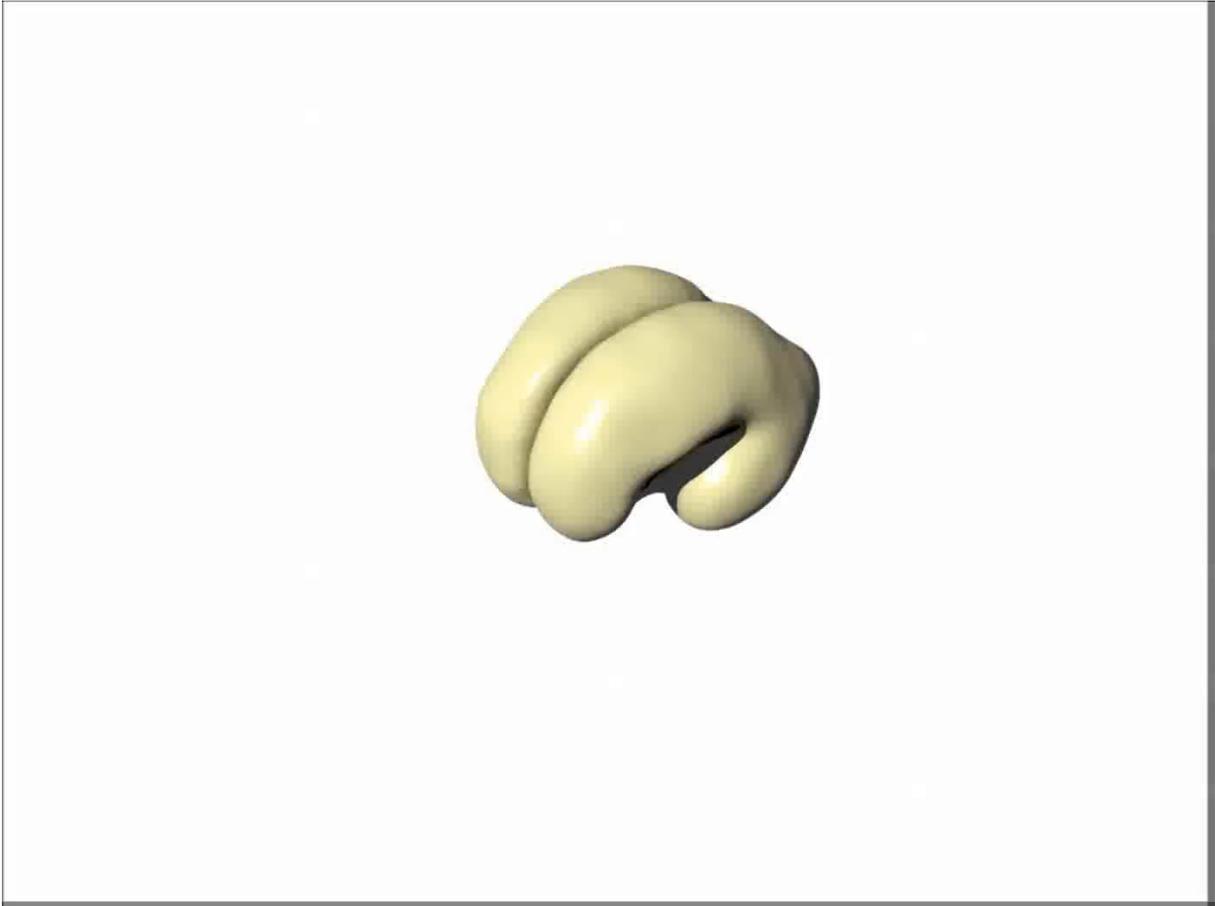
Simulación numérica

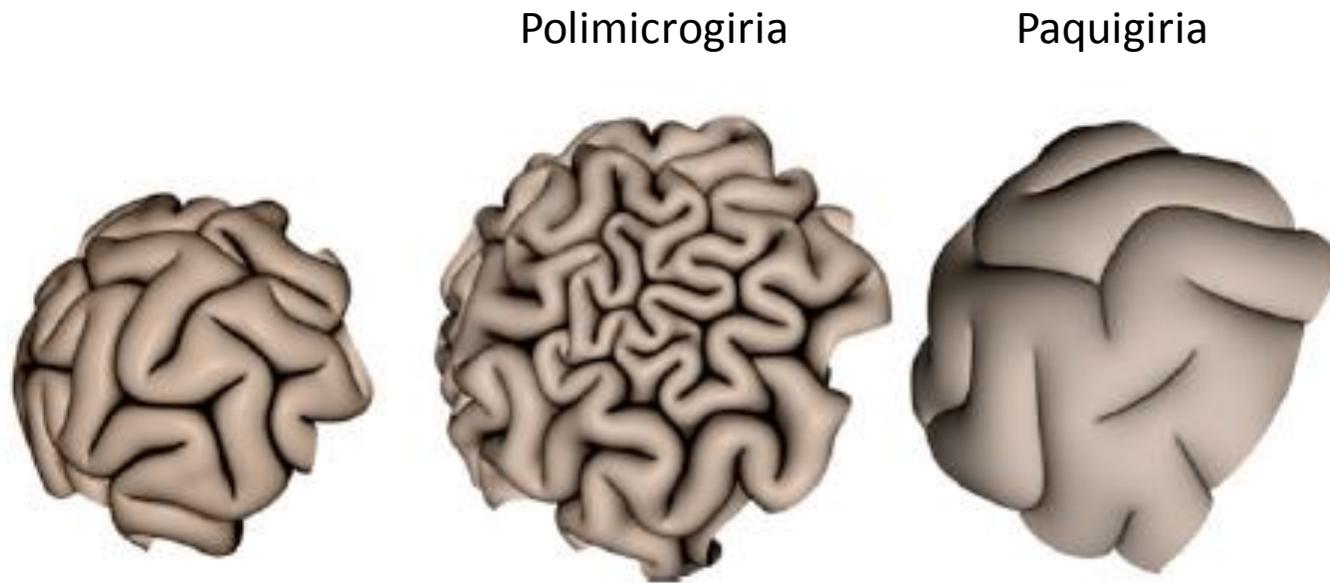
Densidad de energía volumétrica

$$\mathcal{W} = \frac{\mu}{2} \left[\text{Tr}(\mathbf{F}\mathbf{F}^T) J^{-2/3} - 3 \right] + \frac{K}{2} (J - 1)^2$$

Crecimiento tangencial

$$g(y) = 1 + \frac{\alpha}{1 + e^{10(y/T - 1)}}$$



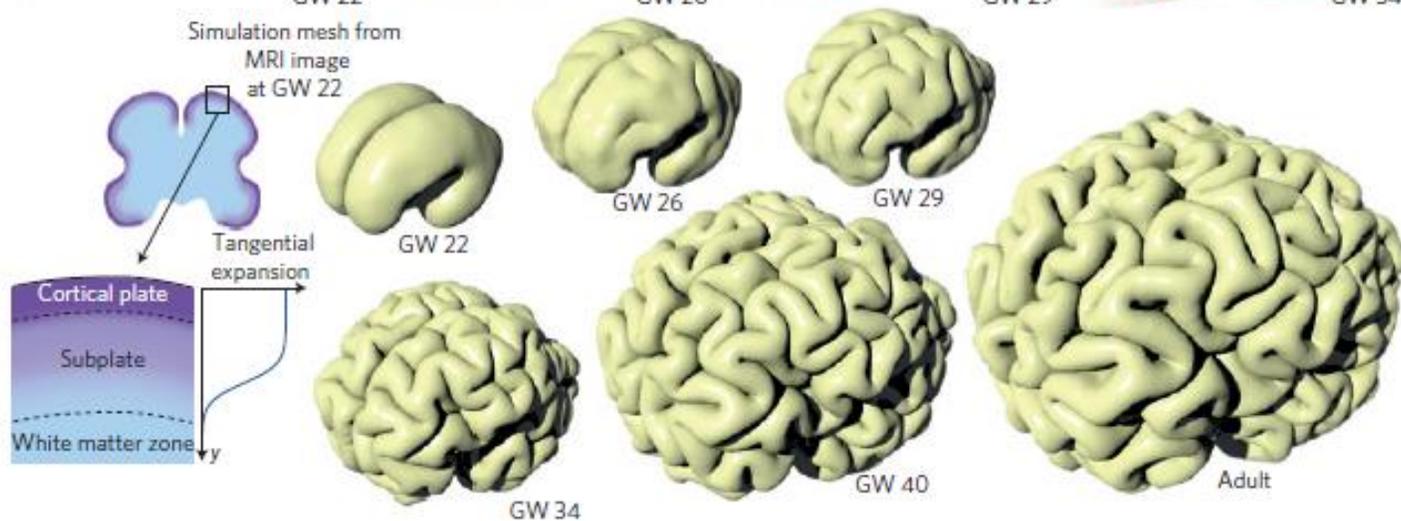
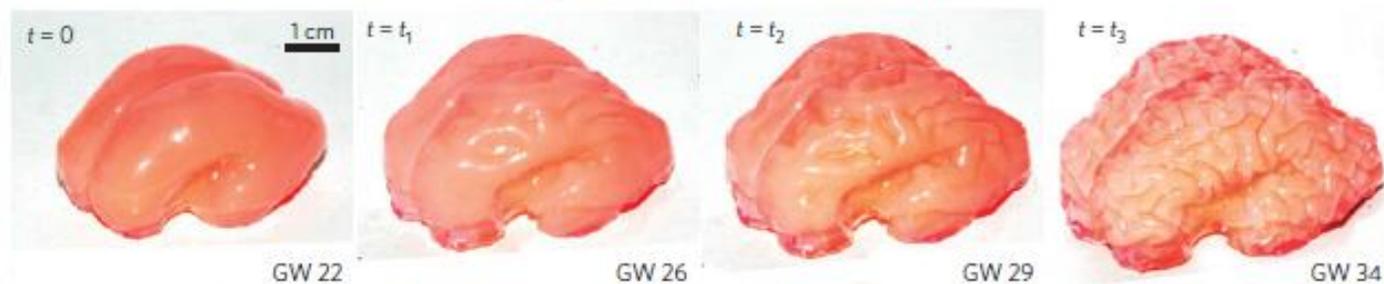
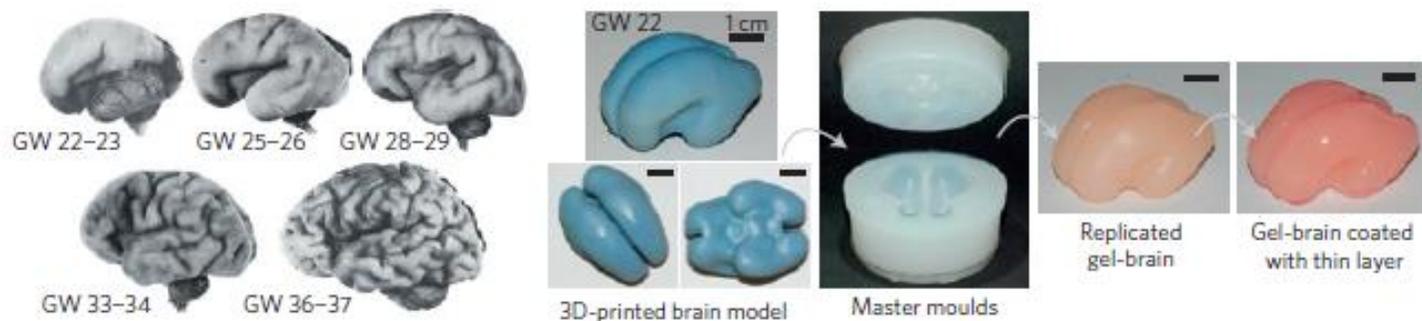


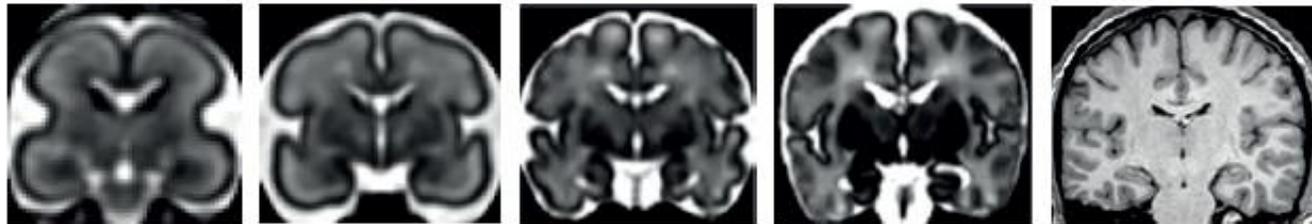
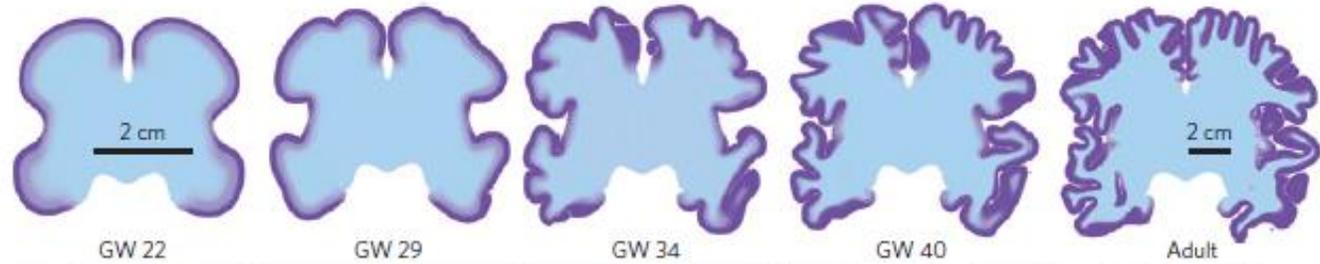
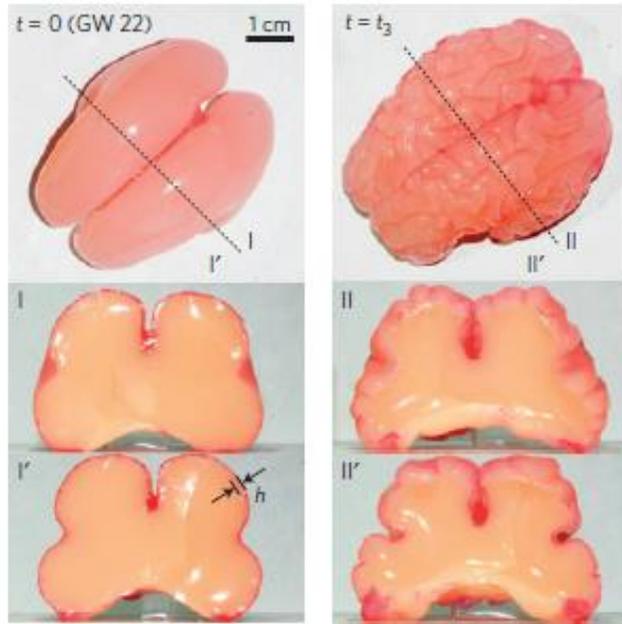
Polimicrogria

Paquigiria

Menor espesor → polimicrogria

Menor crecimiento cortical → paquigiria





Conclusión

El origen de las circunvoluciones se puede explicar por el crecimiento asimétrico de dos capas de igual rigidez como se demuestra a través del modelo físico y la simulación numérica.

Muchas Gracias

