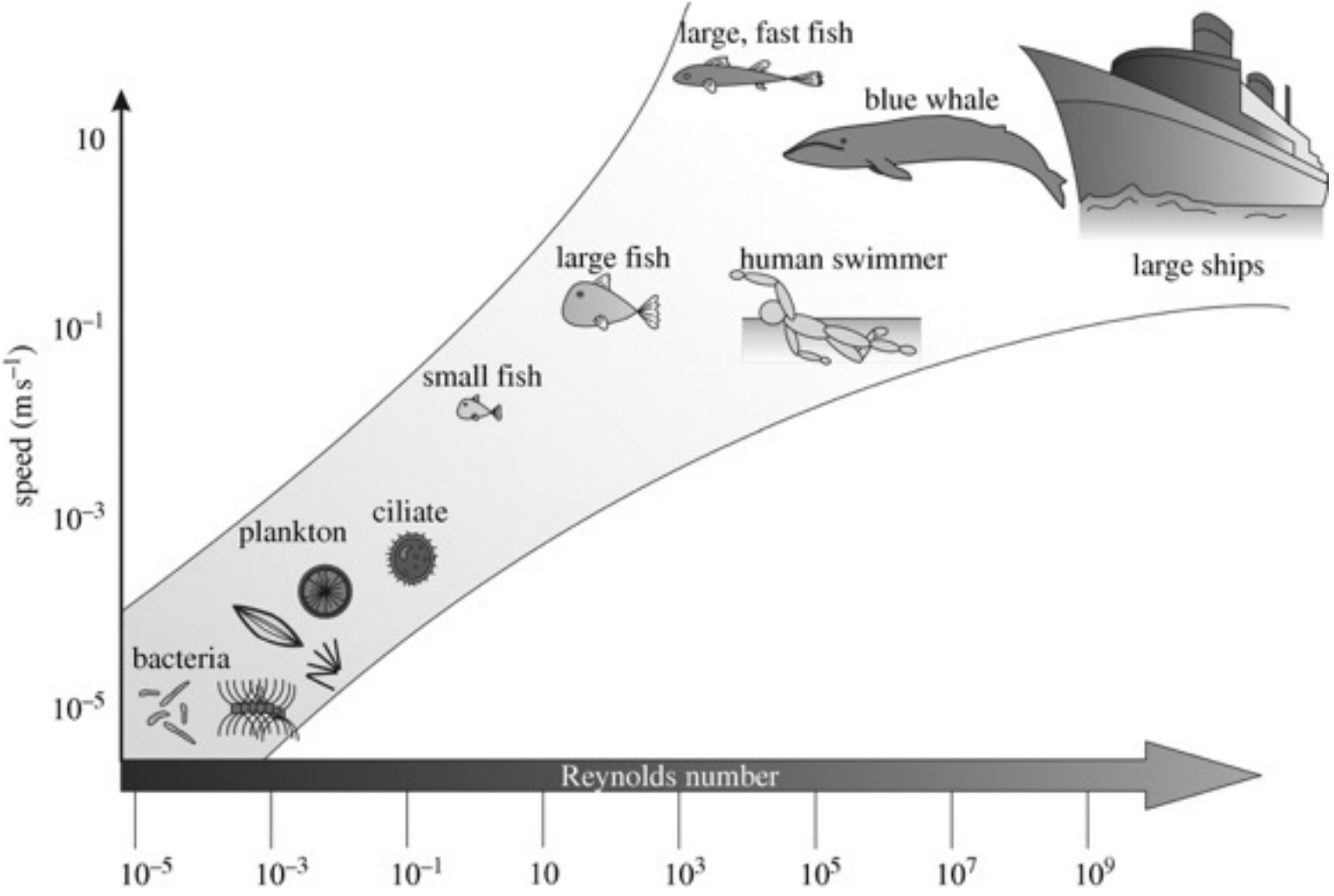
Biology 427 2015
Lecture 25. Life at Low Reynolds Numbers

Posters Due Mon Dec 5, 5 pm

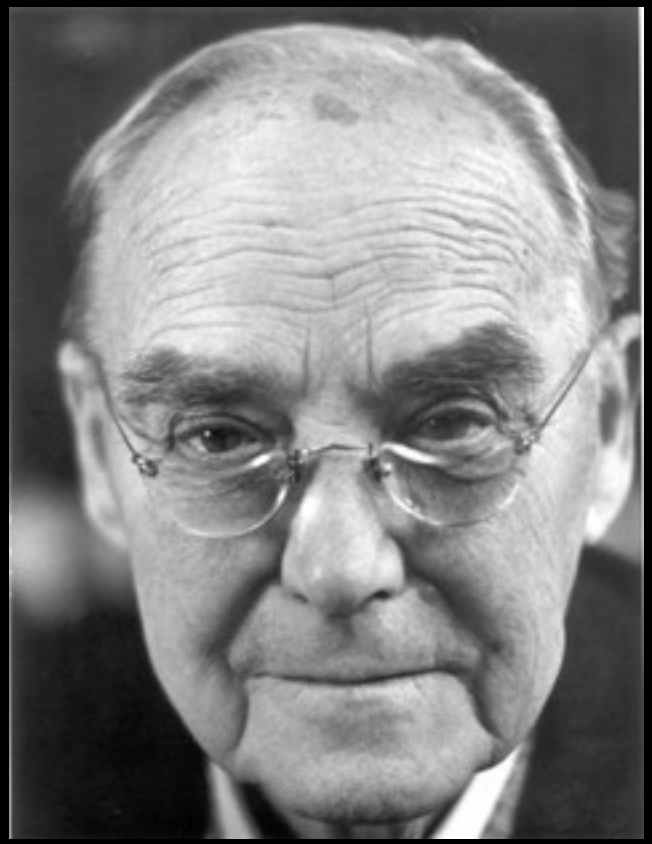
- Low Reynolds numbers
- Principles of low Re flows
- Gliding bacteria
- Vesicle transport
- Spores illustrated



Designing biomimetic antifouling surfaces

Maria Salta, Julian A. Wharton, Paul Stoodley, Simon P. Dennington, Liam R. Goodes, Stéphane Werwinski, Ugar Mart, Robert J. K. Wood, Keith R. Stokes

Published 20 September 2010.DOI: 10.1098/rsta.2010.0195



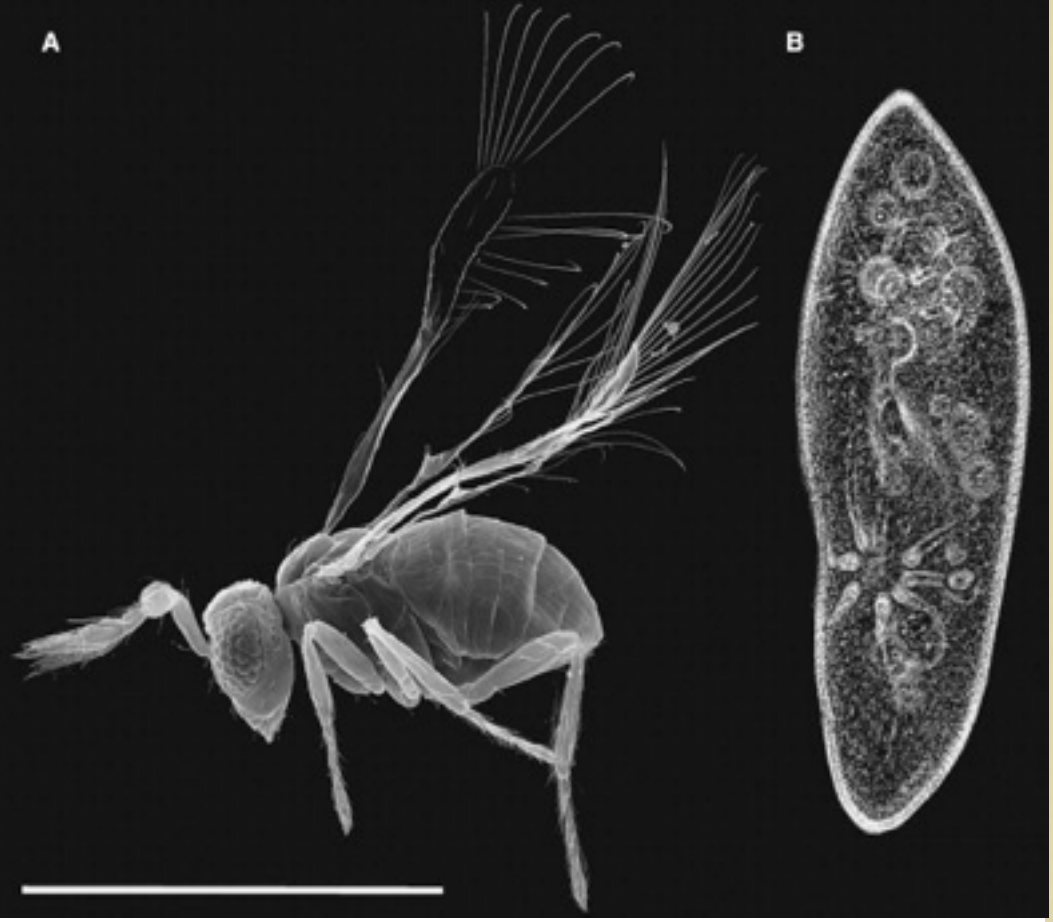
Sir G. I. Taylor

Taylor cone
Taylor dispersion
Taylor number
Taylor vortex
Taylor–Couette flow
Taylor–Goldstein equation
Rayleigh–Taylor instability
Taylor–Proudman theorem
Taylor–Green vortex
Taylor microscale
Taylor column

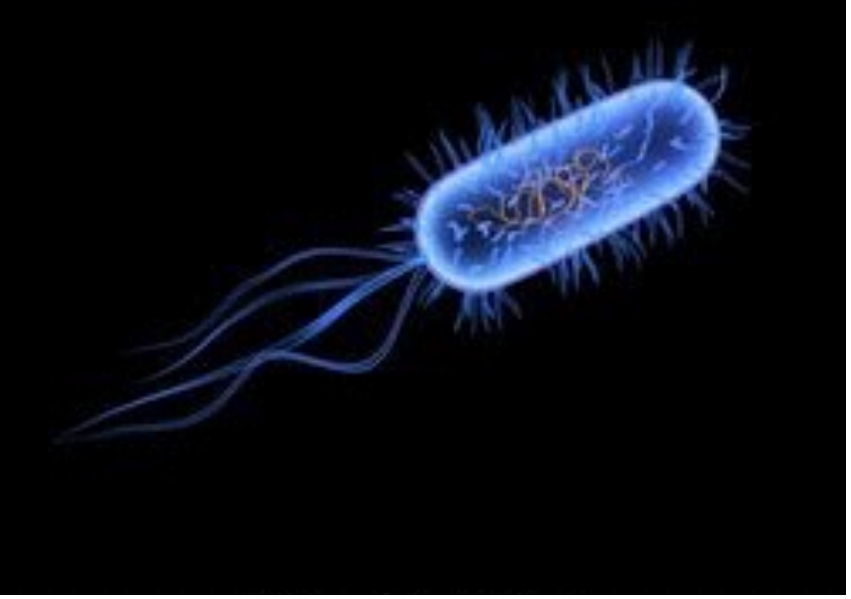
Life at Low Reynolds numbers (Re <<1)

Phenomenological issues:

- disturbances are manifest over huge relative distances. (boundaries are all important)
- inertia is negligible
- flow is reversible (flow equations are linear)
- shape matters considerably less (no wakes)



Mymarid wasps:
paddles versus rakes



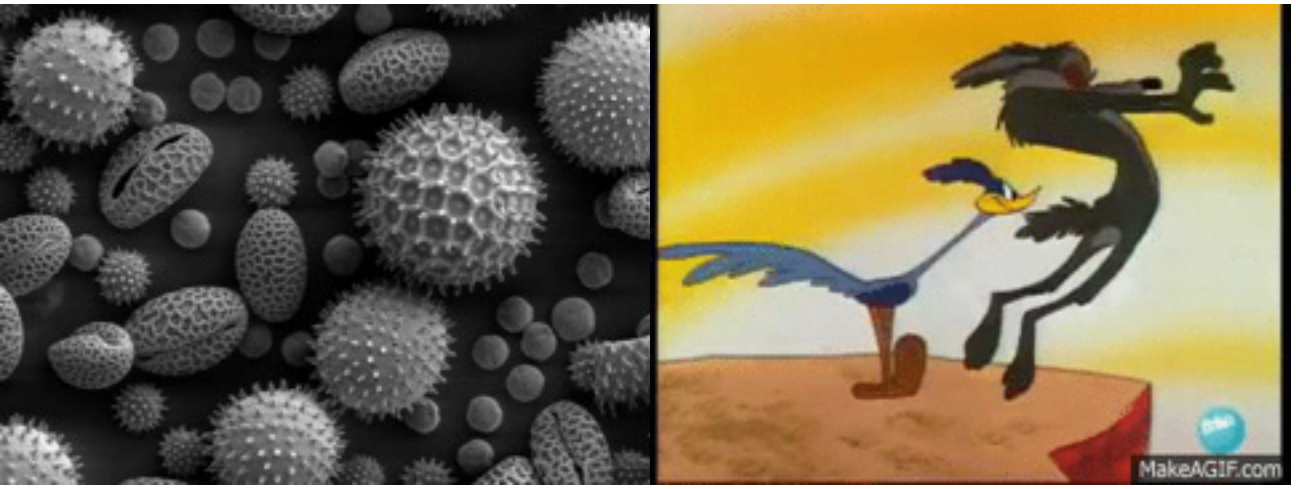
How far will this glide if the flagella stop?

$$m\frac{dU}{dt} = 6\pi r\mu U$$

$$U = U_o e^{-6\pi r t\mu/m}$$

A Mathematica demonstration

Spores illustrated: what is their trajectory upon ejection?

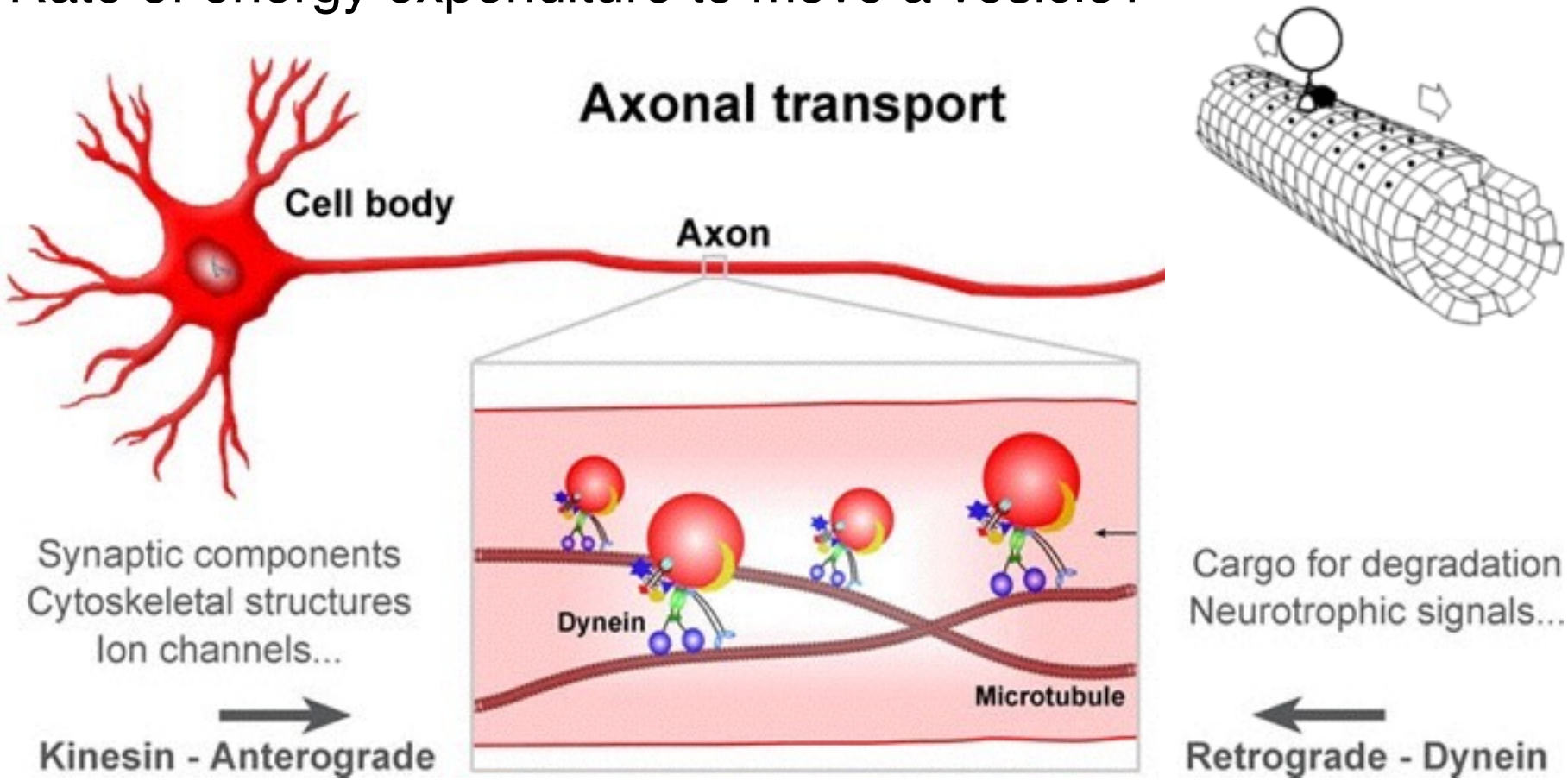


$$m\frac{dU}{dt} = 6\pi r\mu U$$

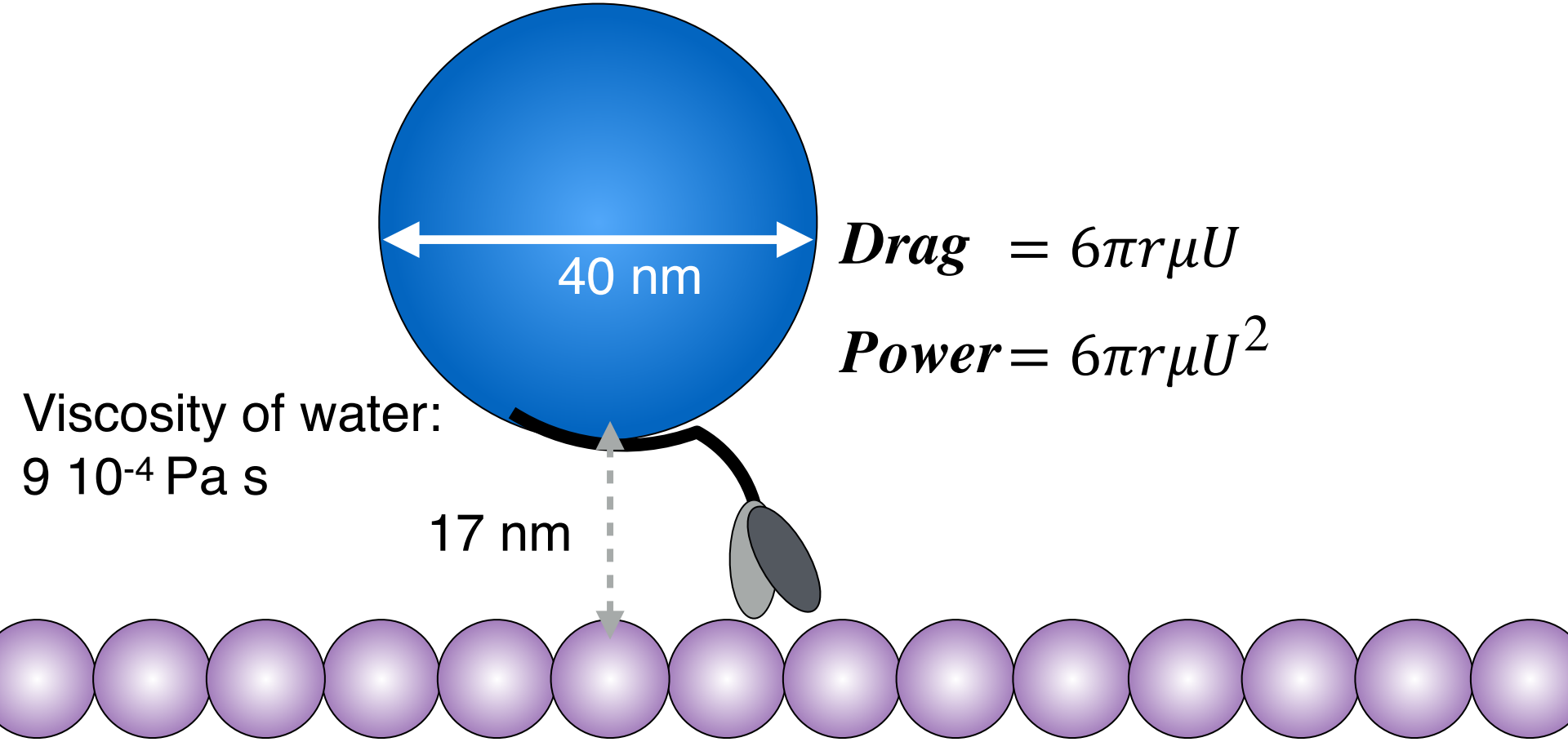
$$m\frac{dV}{dt} = 6\pi r\mu V - mg$$

A Mathematica demonstration

Axonal transport:
Rate of energy expenditure to move a vesicle?



https://web.stanford.edu/group/cui/research.html



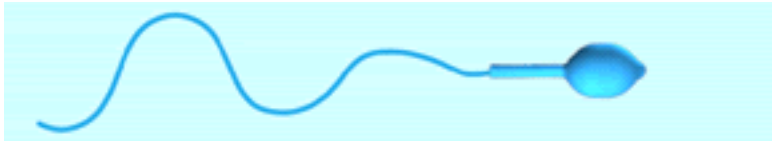
$$\textbf{\textit{Drag}} = 6\pi r\mu U$$

$$\textbf{\textit{Power}} = 6\pi r\mu U^2$$

Viscosity of water:
$9\ 10^{-4}$ Pa s

Data: 400 mm/day
step size = 8 nm.
How many steps/second?
How many ATP/second ?

Data: 1 ATP : $9\ 10^{-20}$ J
How many J/second ?
How fast?



$$D = \frac{4\pi\mu U \mu l}{\ln\left(\frac{l}{a}\right) + 0.193}$$

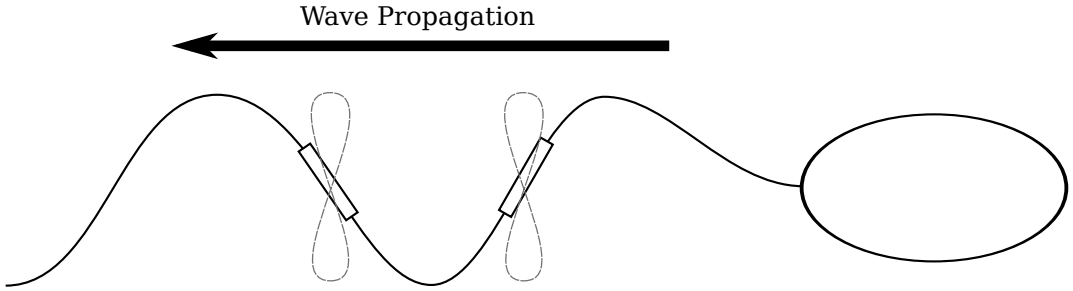
Cross flow

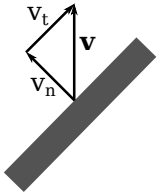
$$D = \frac{2\pi\mu U \mu l}{\ln\left(\frac{l}{a}\right) - 0.897}$$

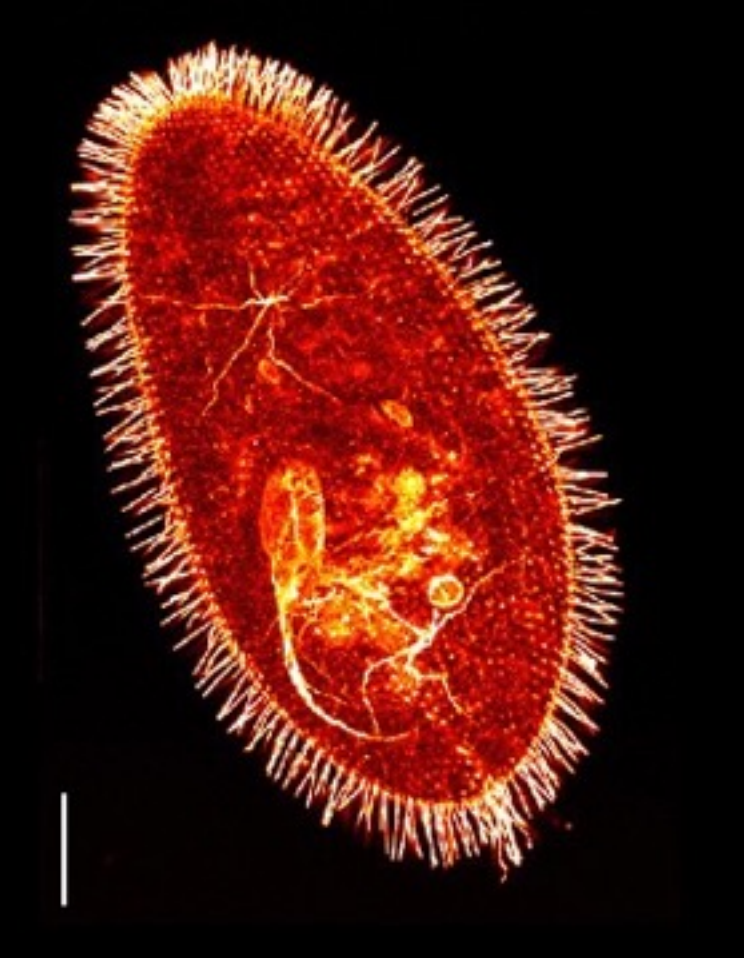
Longitudinal flow

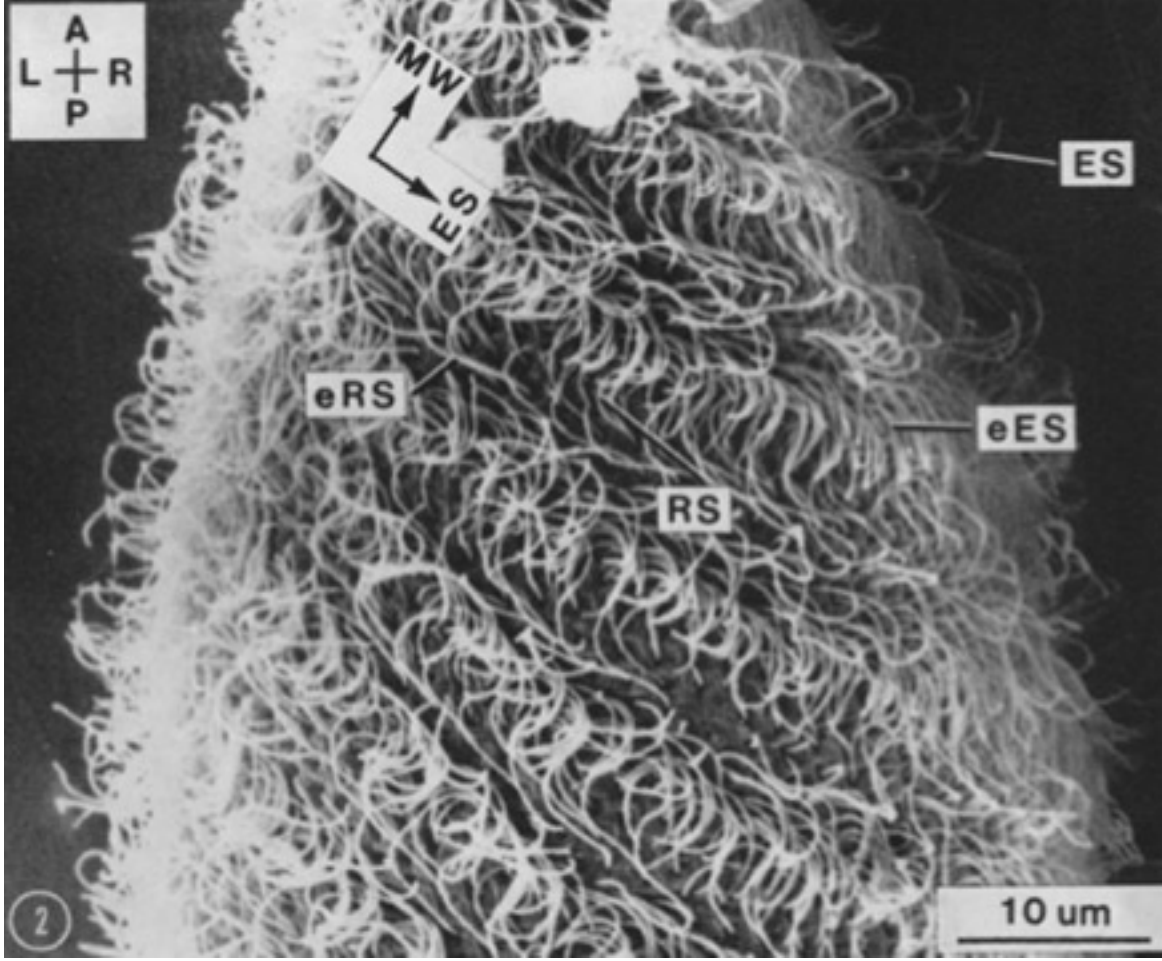
Two questions:

- What are the cellular mechanisms that generate force?
- What are the fluid dynamic mechanisms that propel the animal?





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