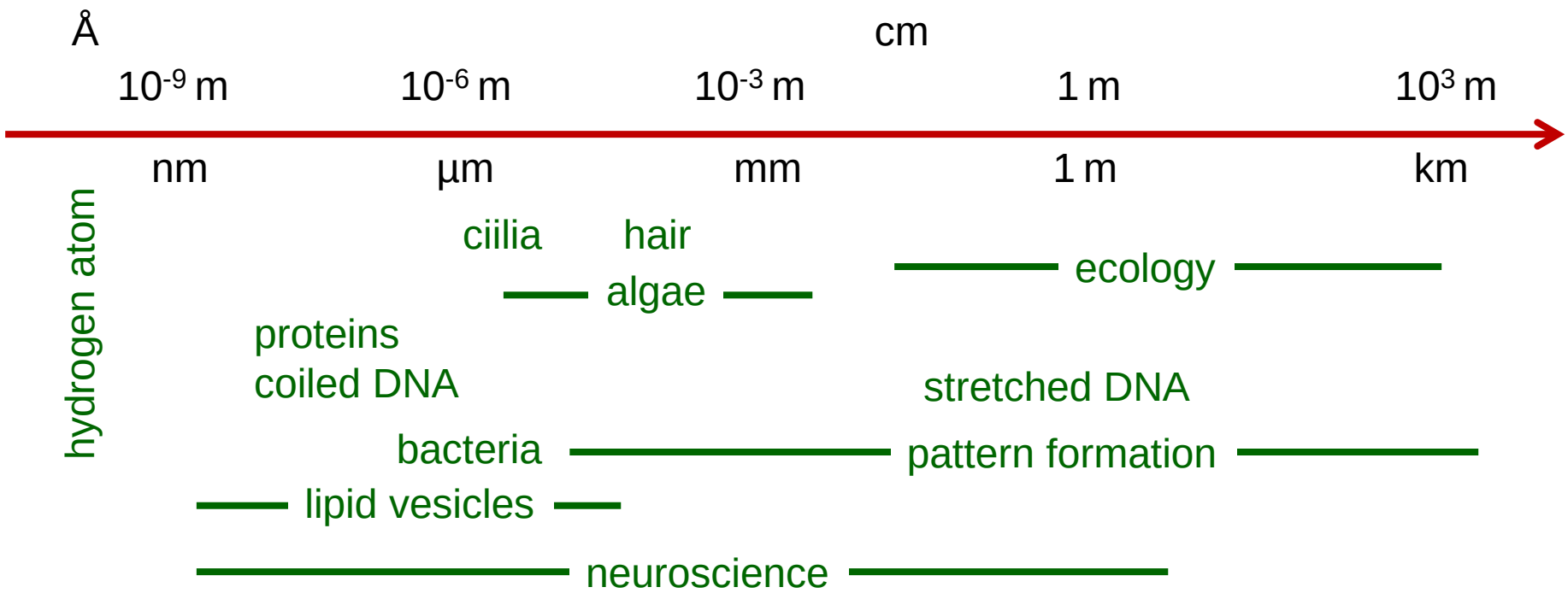
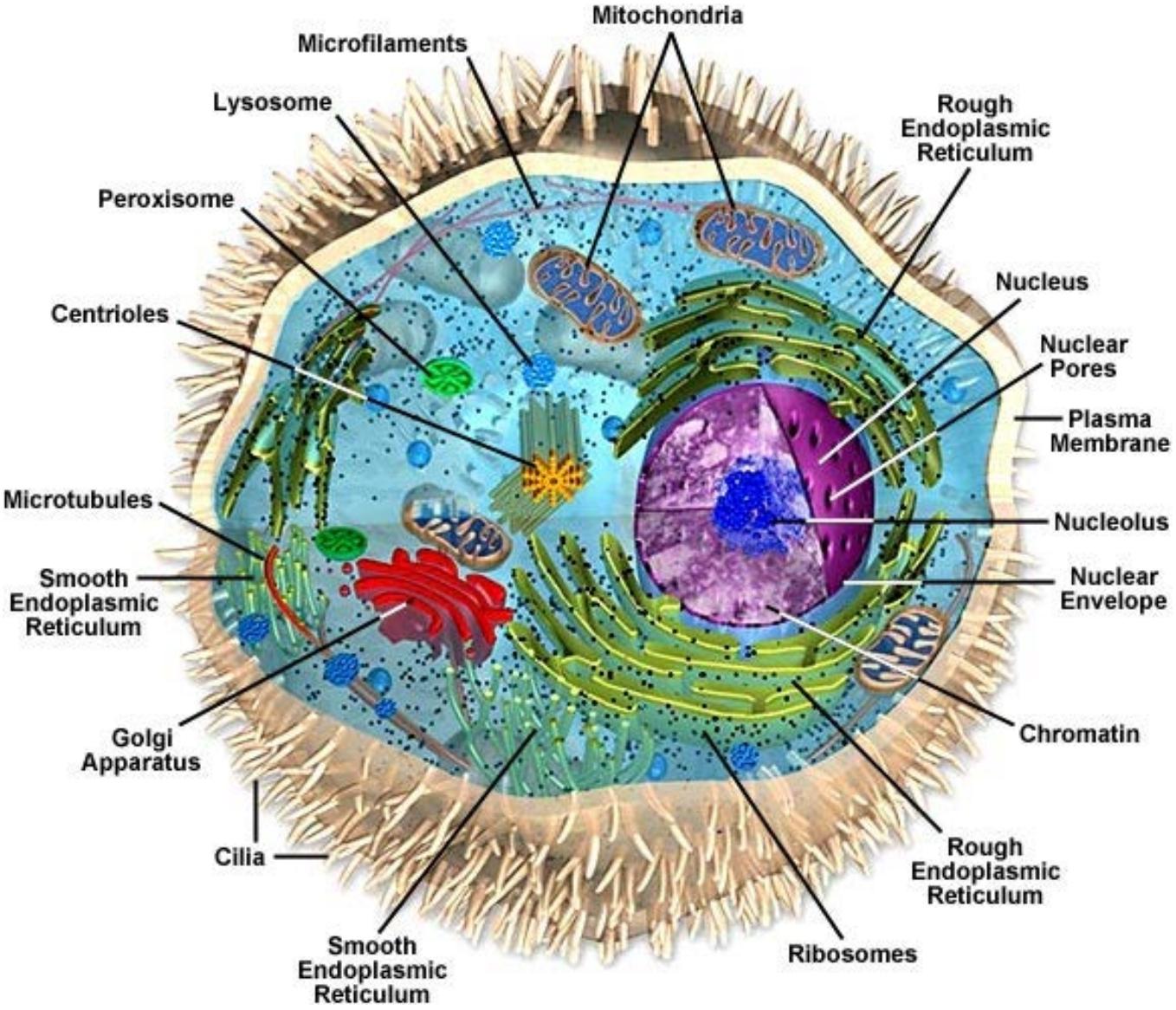
Numbers Matter!



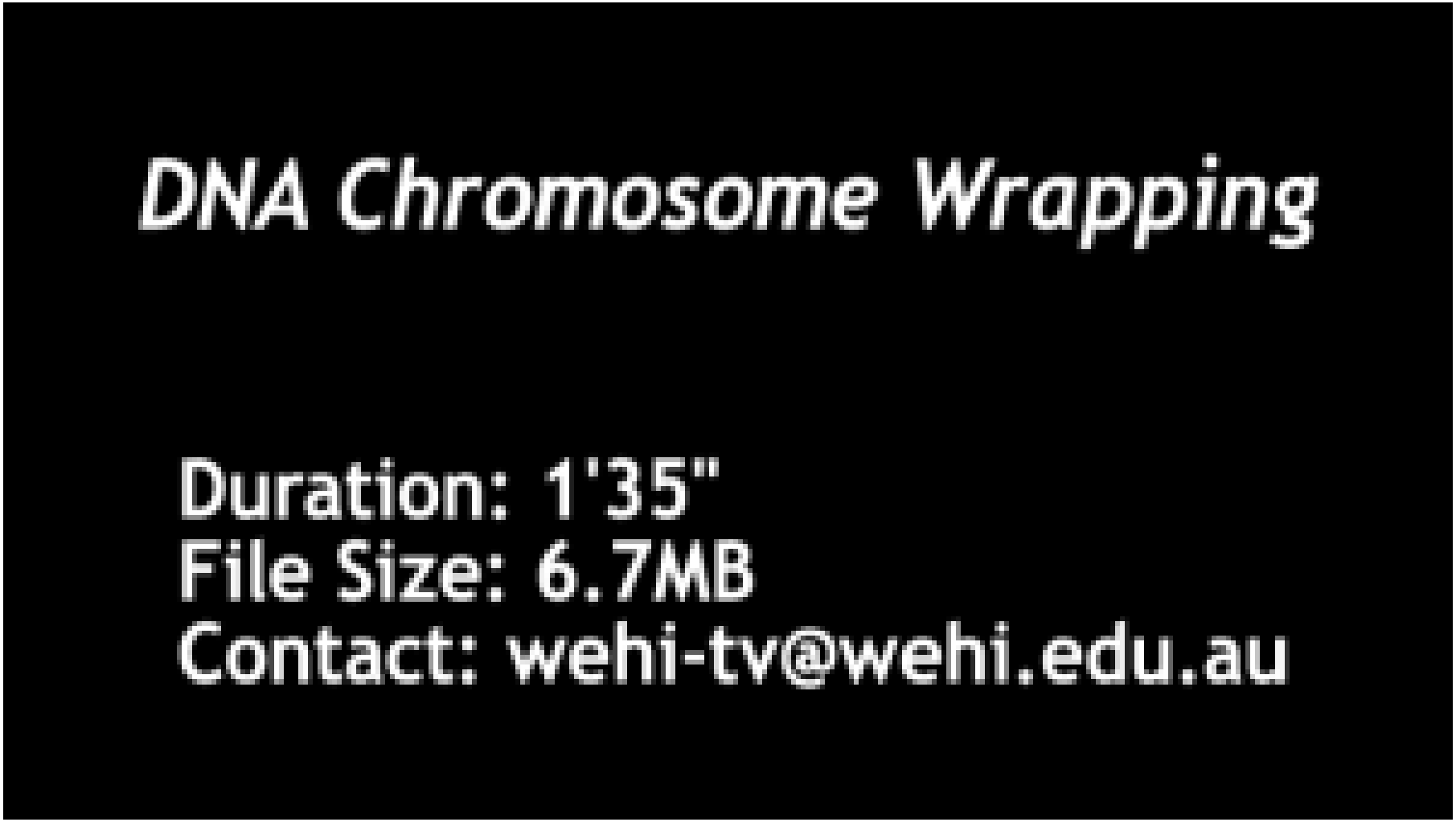
Thermal fluctuations **Other forms of noise**

$$\mu\mathrm{m} = \sqrt{\mathring{\mathrm{A}} \cdot \mathrm{cm}}$$

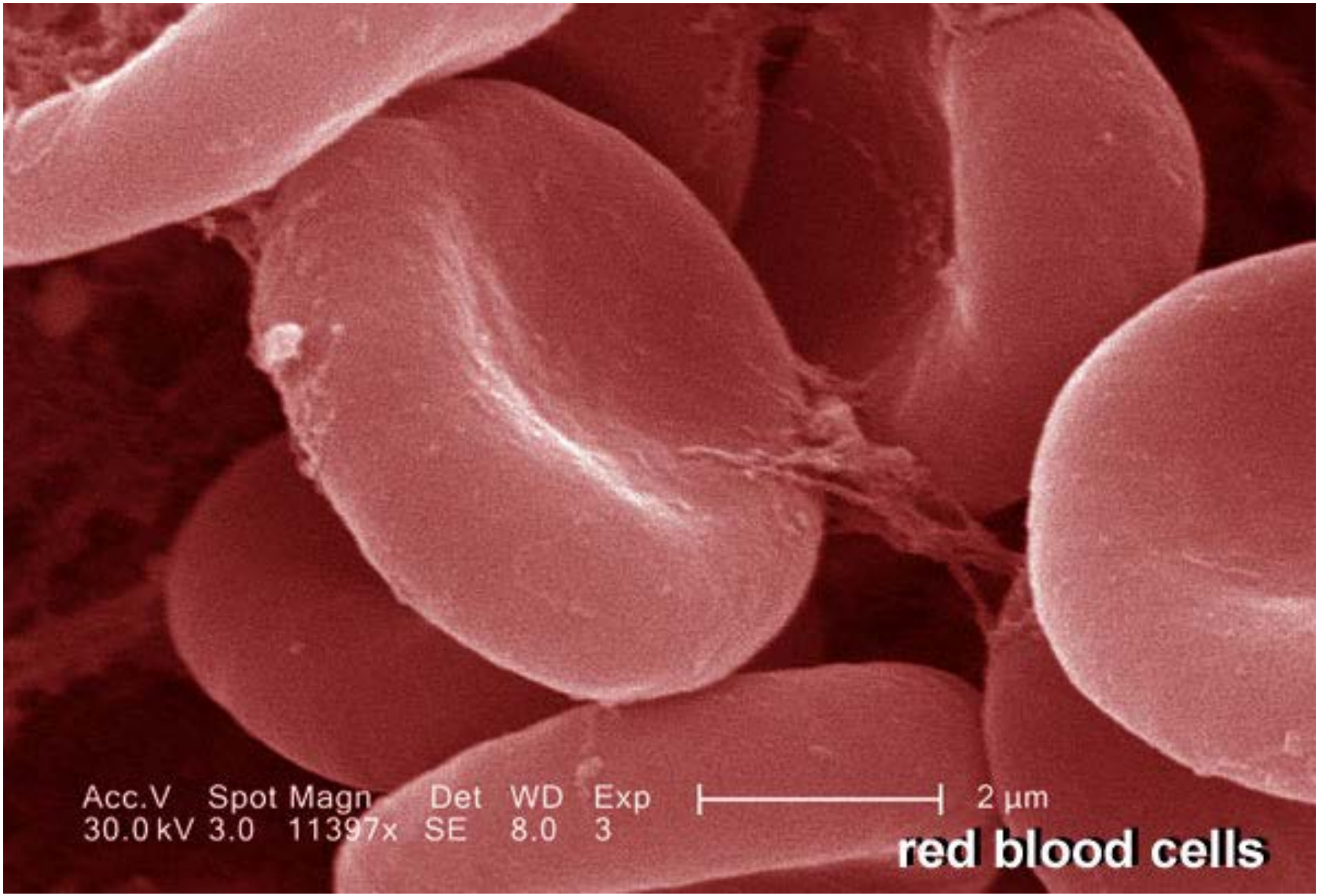
Cells are complicated objects



Hierarchical Chromosome Organization

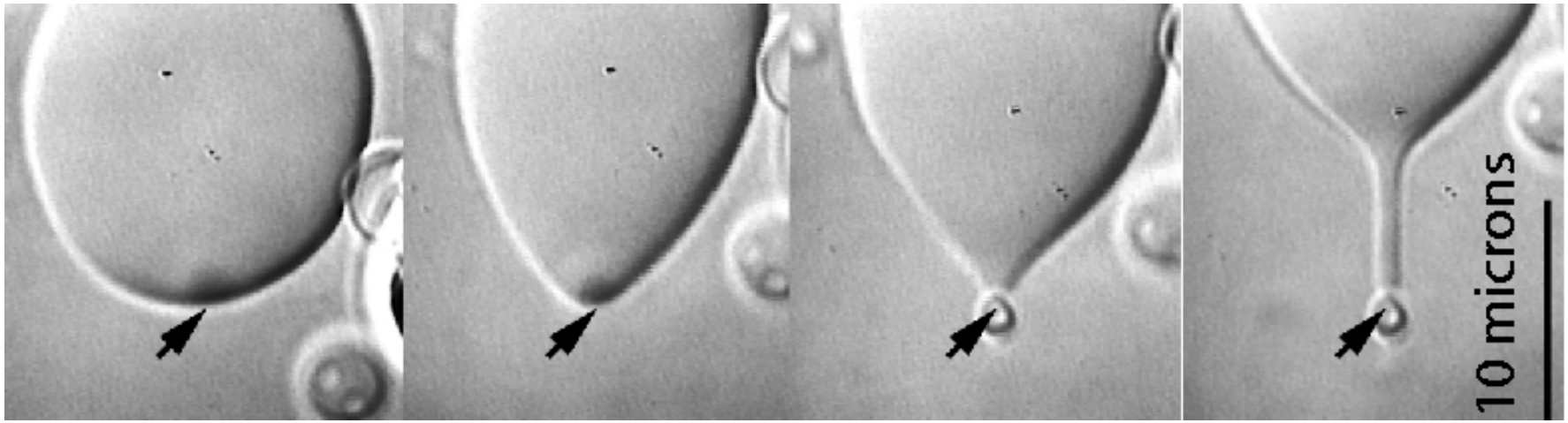


Erythrocytes (Red Blood Cells)



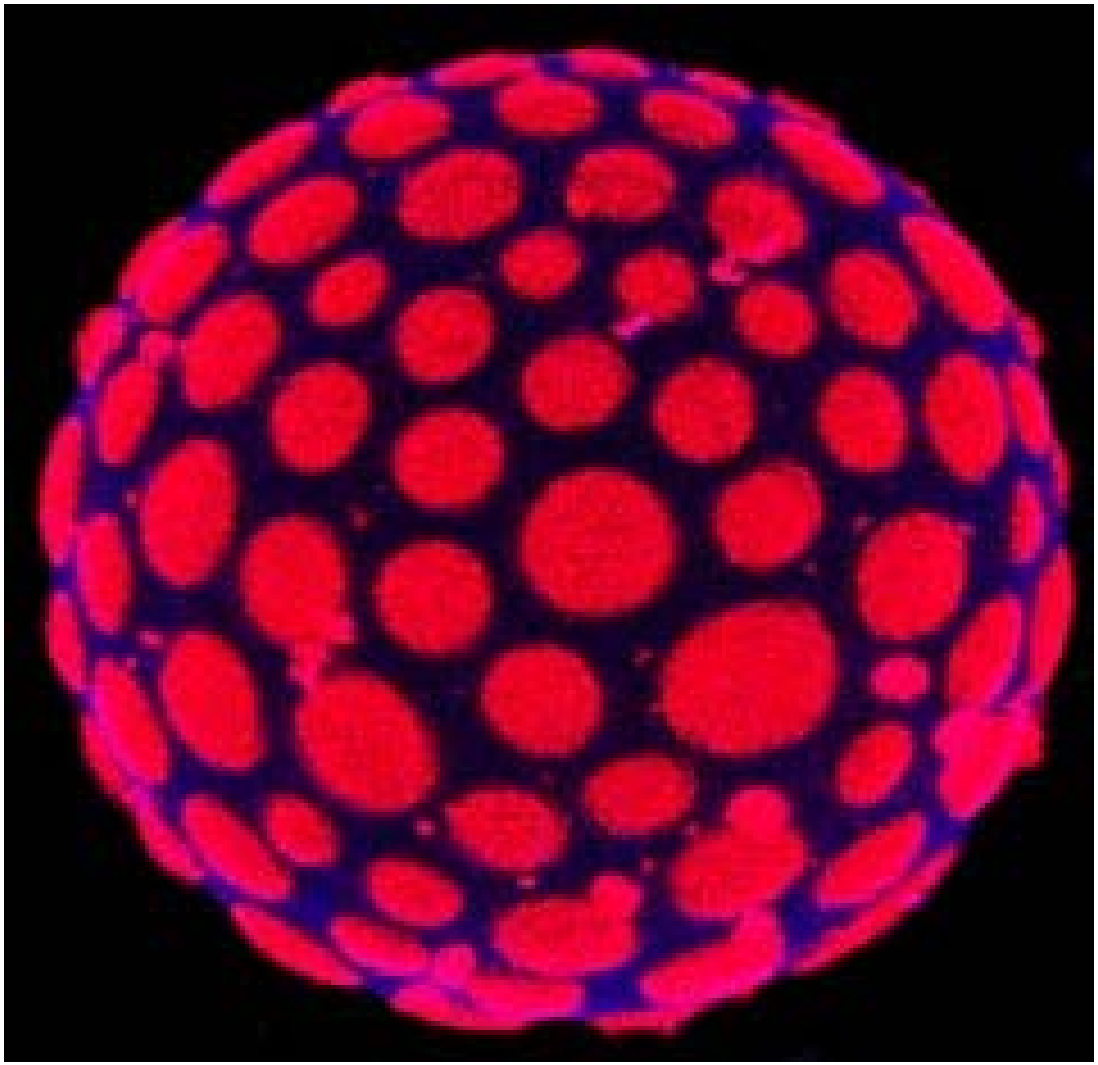
Fluctuating Lipid Vesicle

Artificial Lipid Vesicles – Membrane Tethers



D. Fygenson (UCSB)

Domains on a GUV (Giant Unilamellar Vesicle)



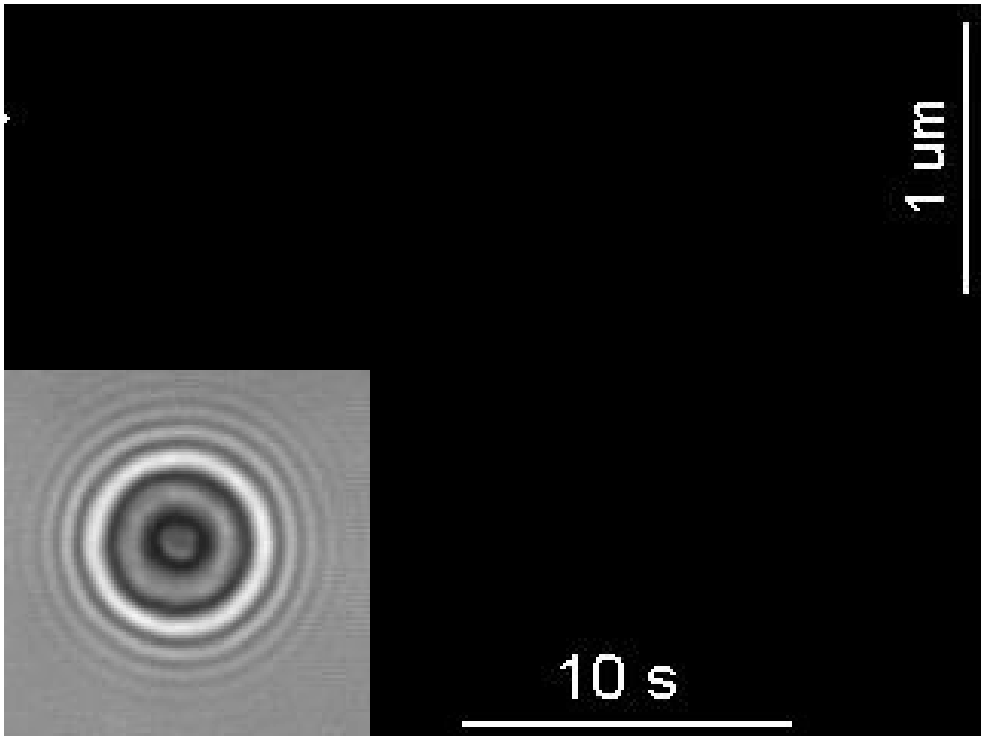
W. Webb (Cornell)

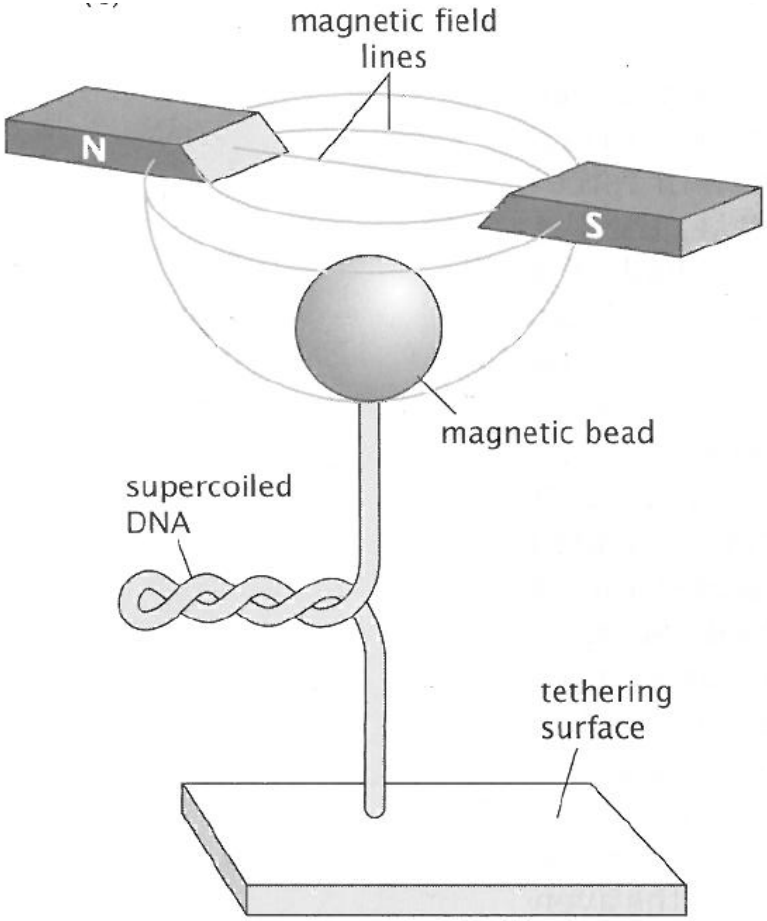
Optical Tweezers: Manipulating Single Molecules

Optical Tweezers: Controlling Particles

Magnetic Tweezers: Coiling DNA

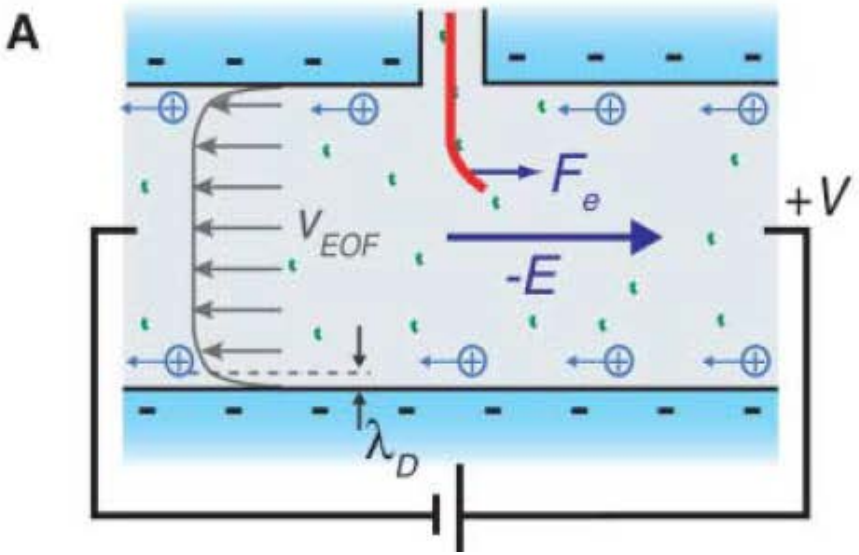
(Seidel 2005)

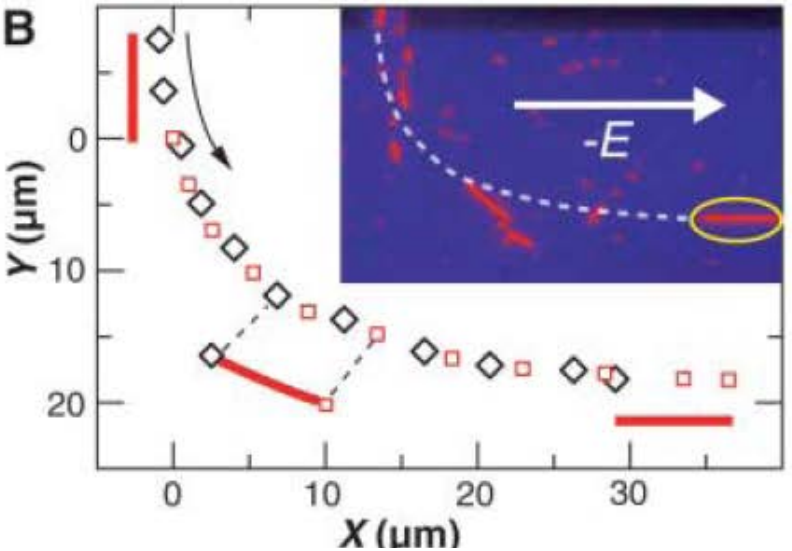


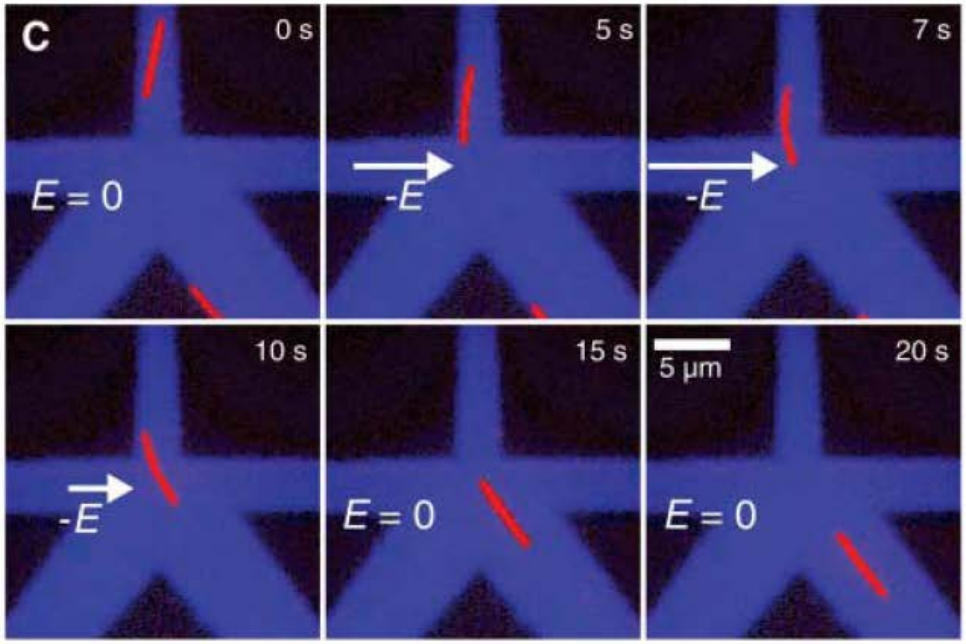


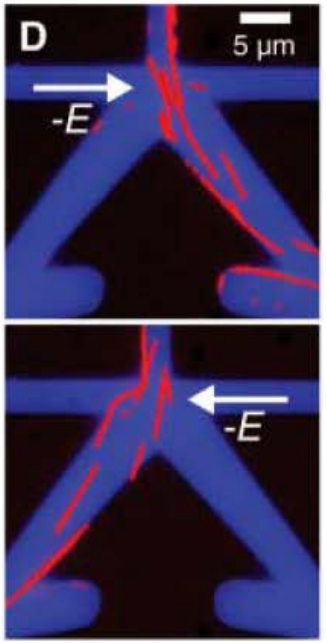
Electrokinetic Effects: Steering Microtubules

Van den Heuvel et al. Science (2006)









Electrokinetics: Steering macromolecules

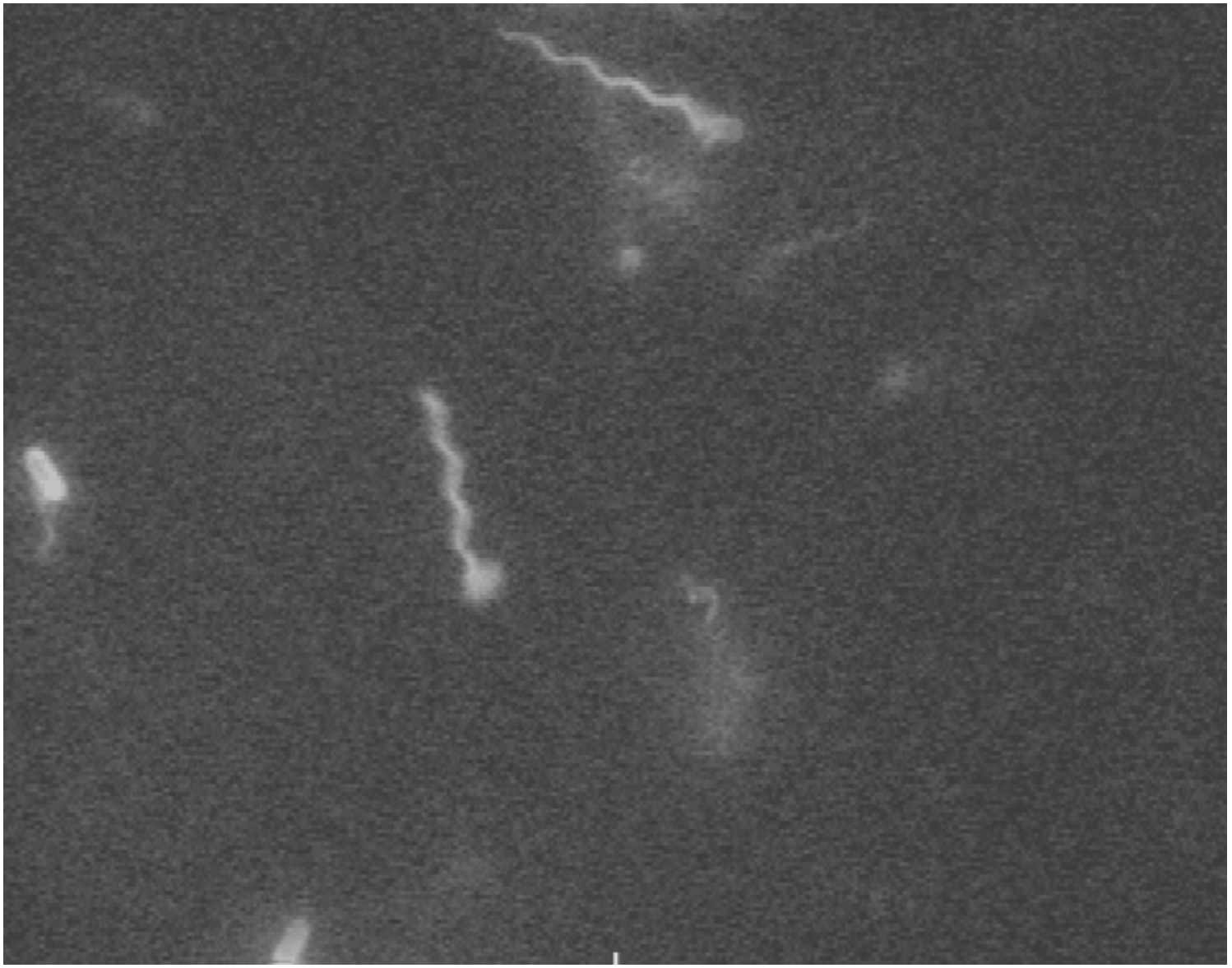
"Molecular sorting of green and red labelled microtubules"

M.G.L. van den Heuvel et.al
Kavli Institute of Nanoscience, Delft

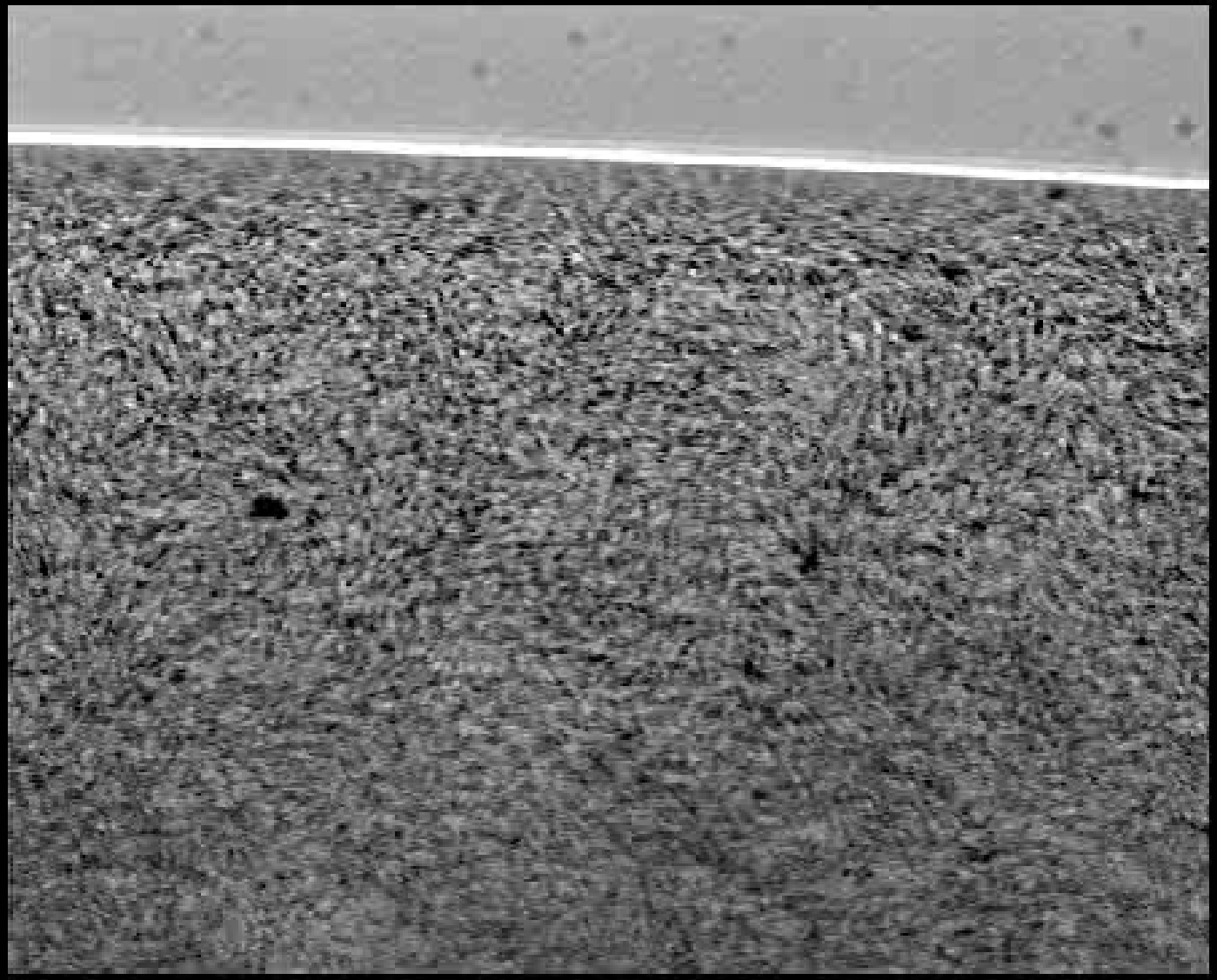
15 x accelerated

Beating Eukaryotic Flagella

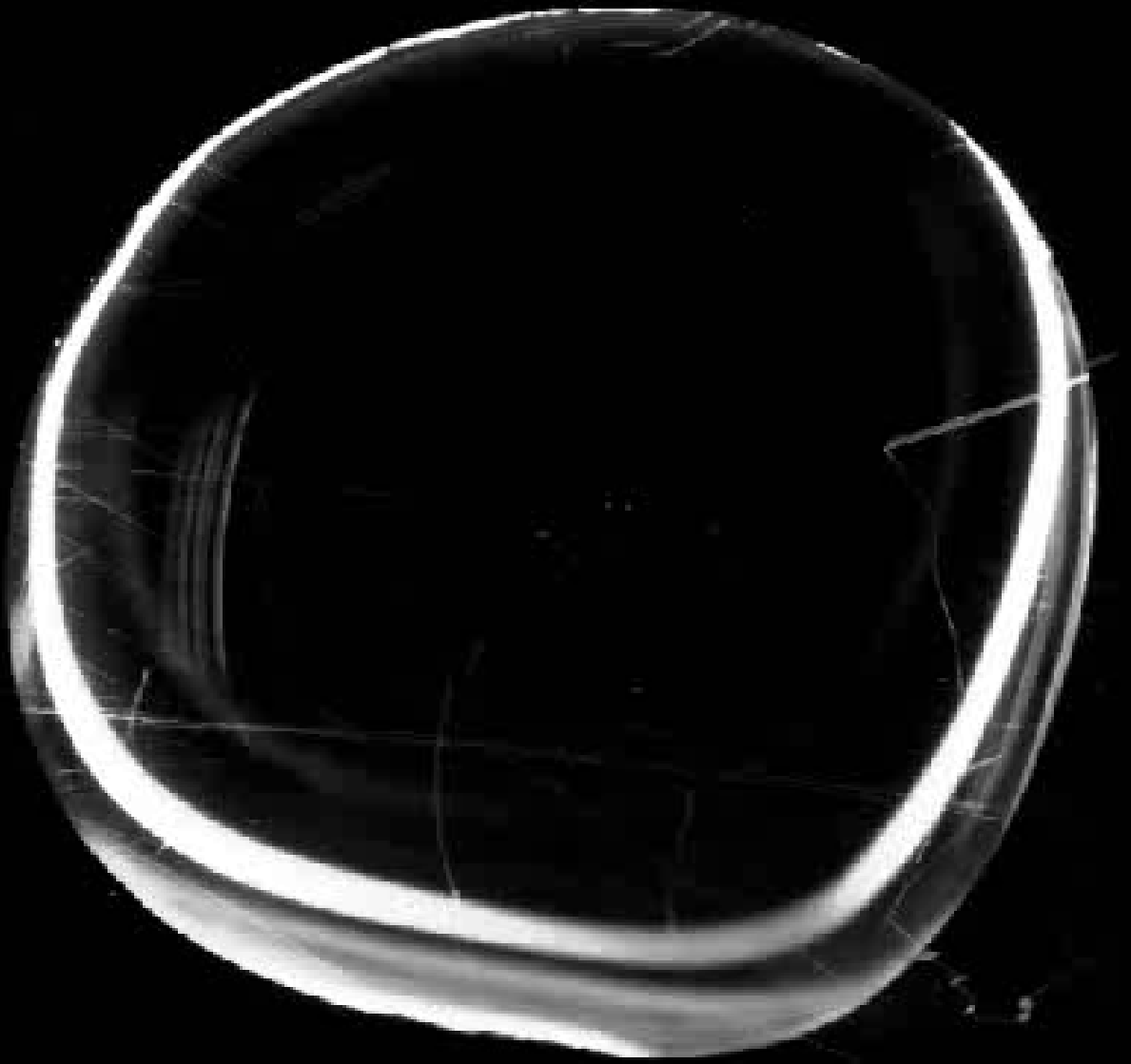
Molecular Motors: Swimming Bacteria



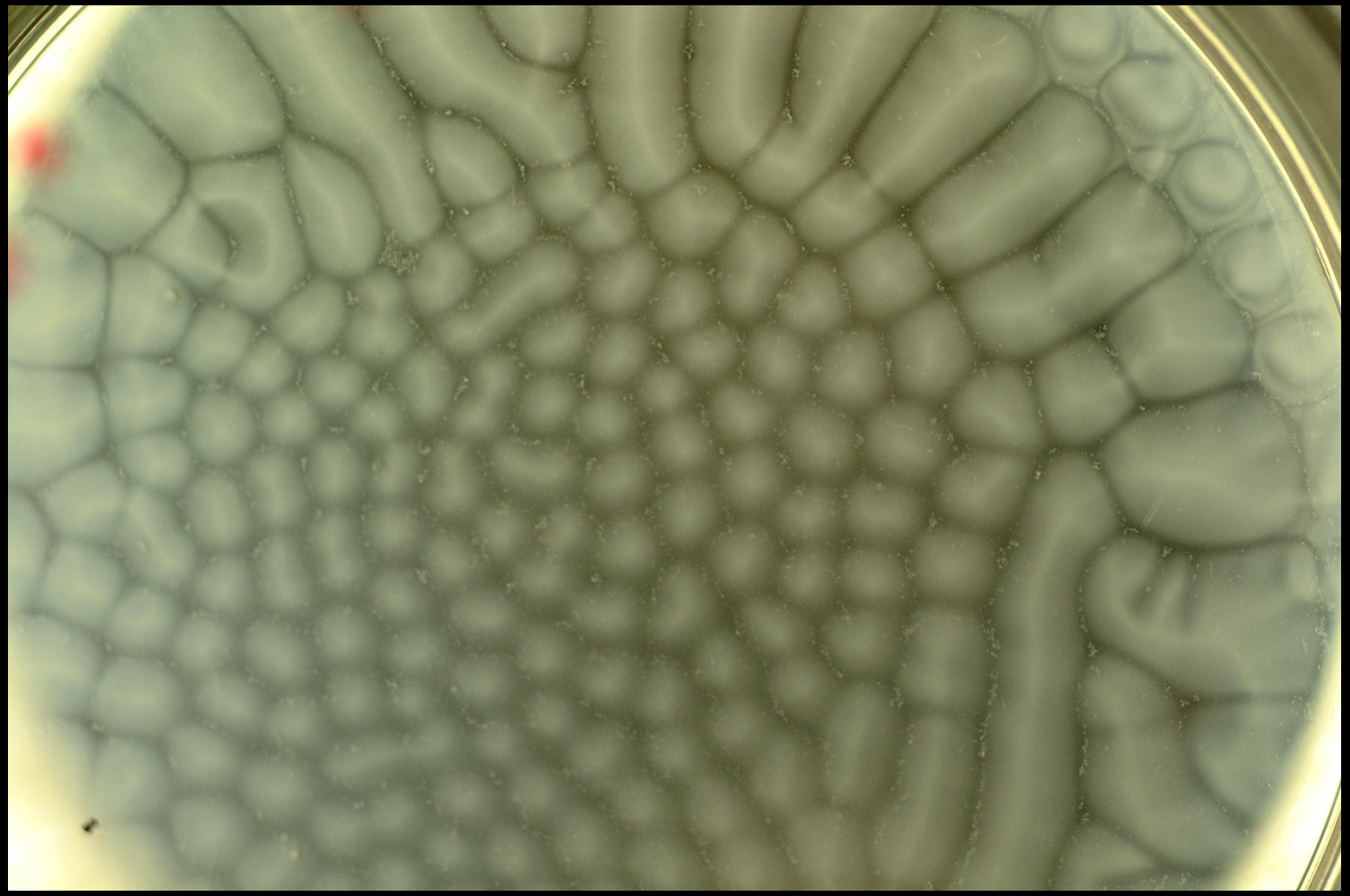
Collective Dynamics in a Bacterial Suspension



Bioconvection



Bioconvective Rolls



Bioconvection (J.O. Kessler)

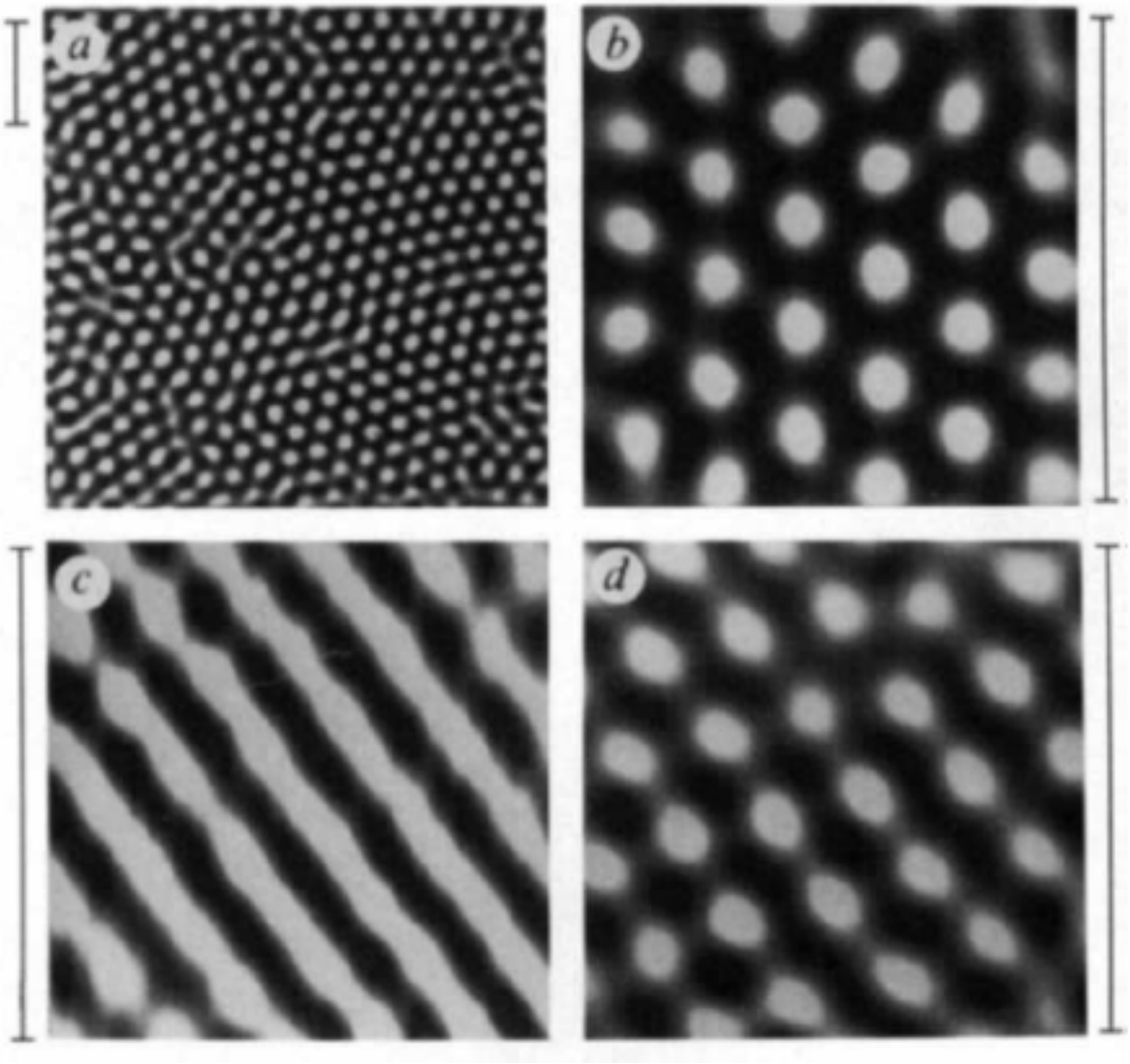
Transition from a uniform state to hexagonal and striped Turing patterns

Q. Ouyang & Harry L. Swinney

Center for Nonlinear Dynamics and Department of Physics,
The University of Texas, Austin, Texas 78712, USA

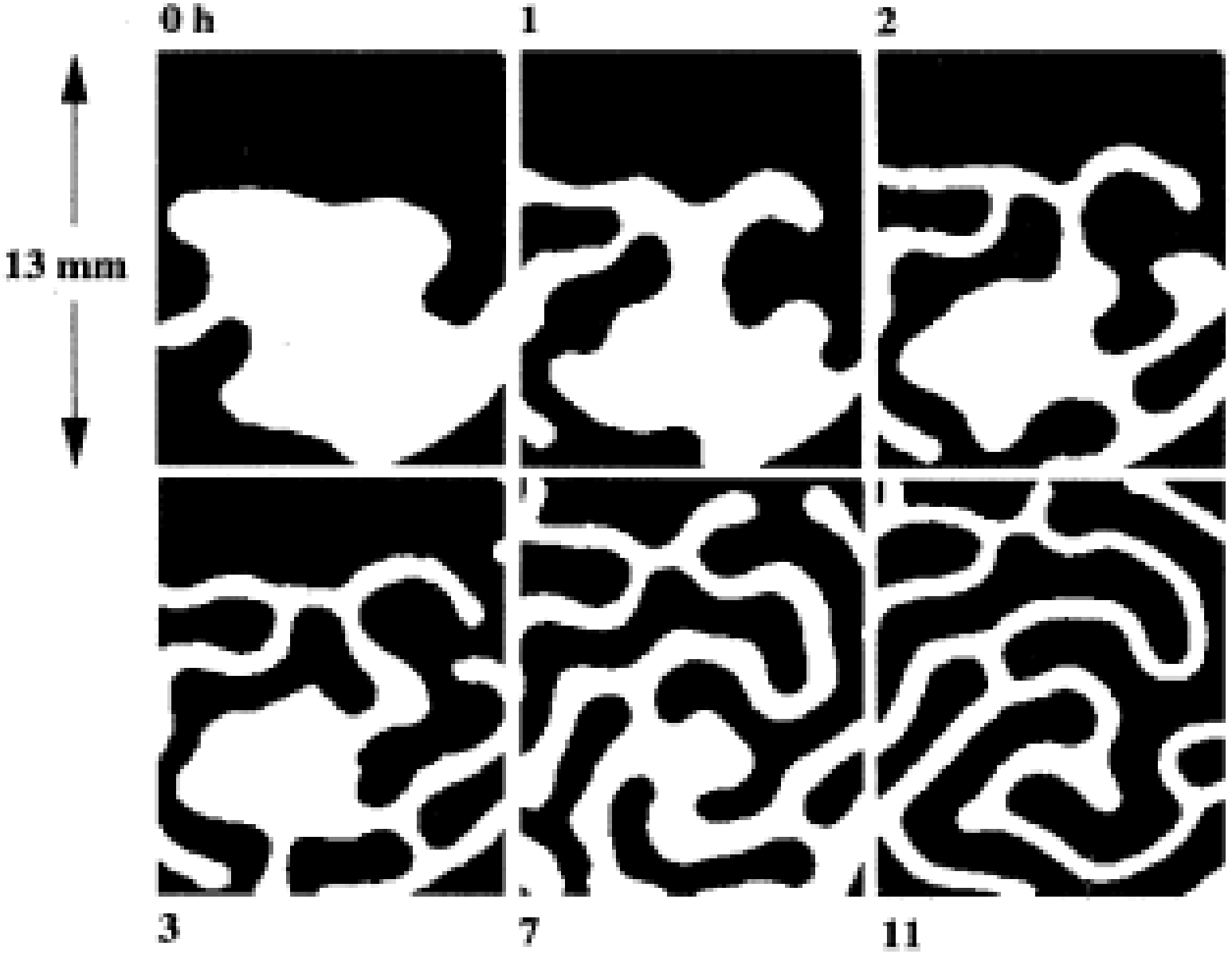
CHEMICAL travelling waves have been studied experimentally for more than two decades[1–5], but the stationary patterns predicted by Turing[6] in 1952 were observed only recently[7–9], as patterns localized along a band in a gel reactor containing a concentration gradient in reagents. The observations are consistent with a mathematical model for their geometry of reactor[10] (see also ref. 11). Here we report the observation of extended (quasi-two-dimensional) Turing patterns and of a Turing bifurcation—a transition, as a control parameter is varied, from a spatially uniform state to a patterned state. These patterns form spontaneously in a thin disc-shaped gel in contact with a reservoir of reagents of the chlorite–iodide–malonic acid reaction[12]. Figure 1 shows examples of the hexagonal, striped and mixed patterns that can occur. Turing patterns have similarities to hydrodynamic patterns (see, for example, ref. 13), but are of particular interest because they possess an intrinsic wavelength and have a possible relationship to biological patterns[14–17].

Classical Turing Patterns



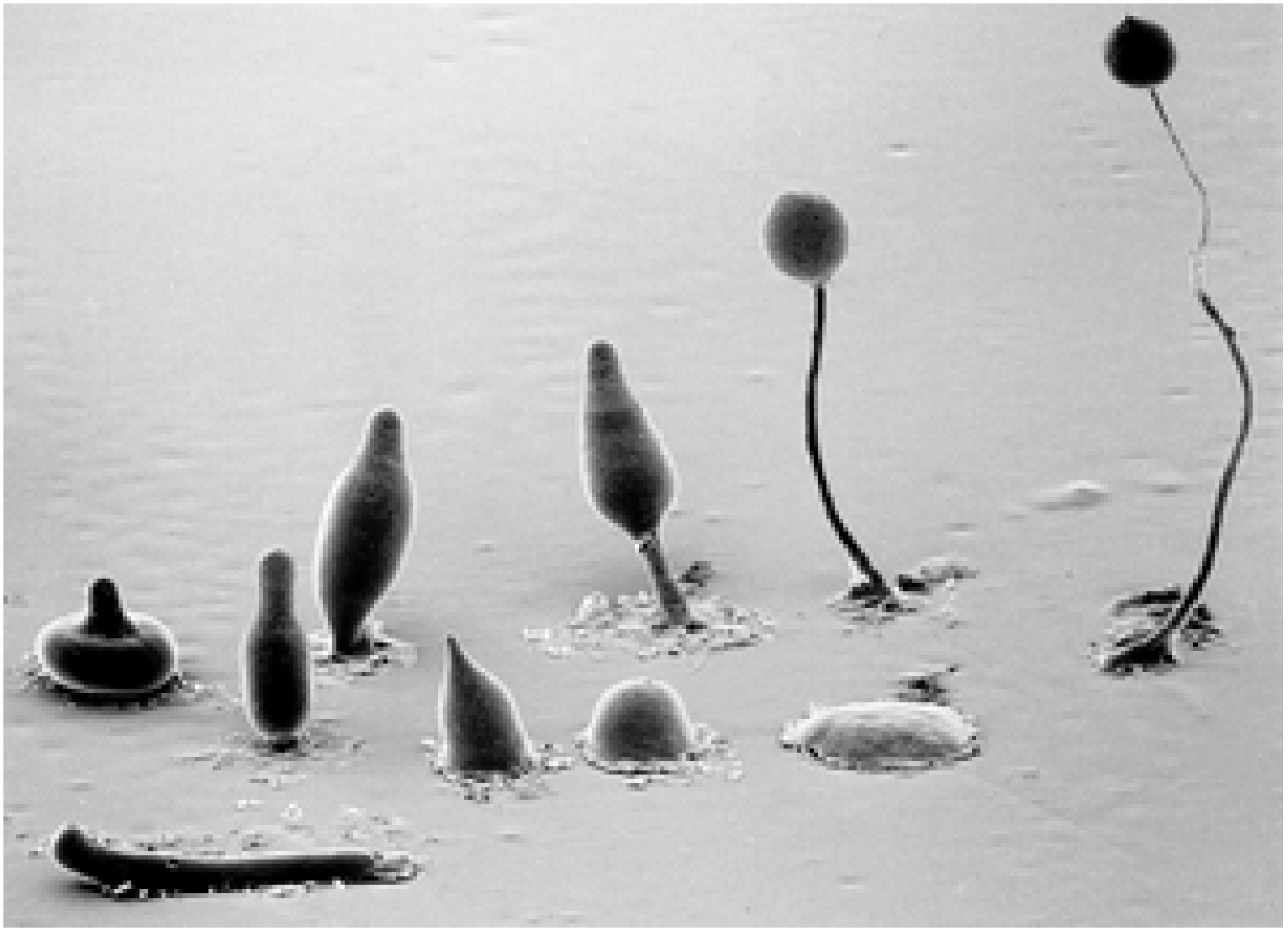
Ouyang and Swinney, 1991 (CIMA)

Unconventional Patterns

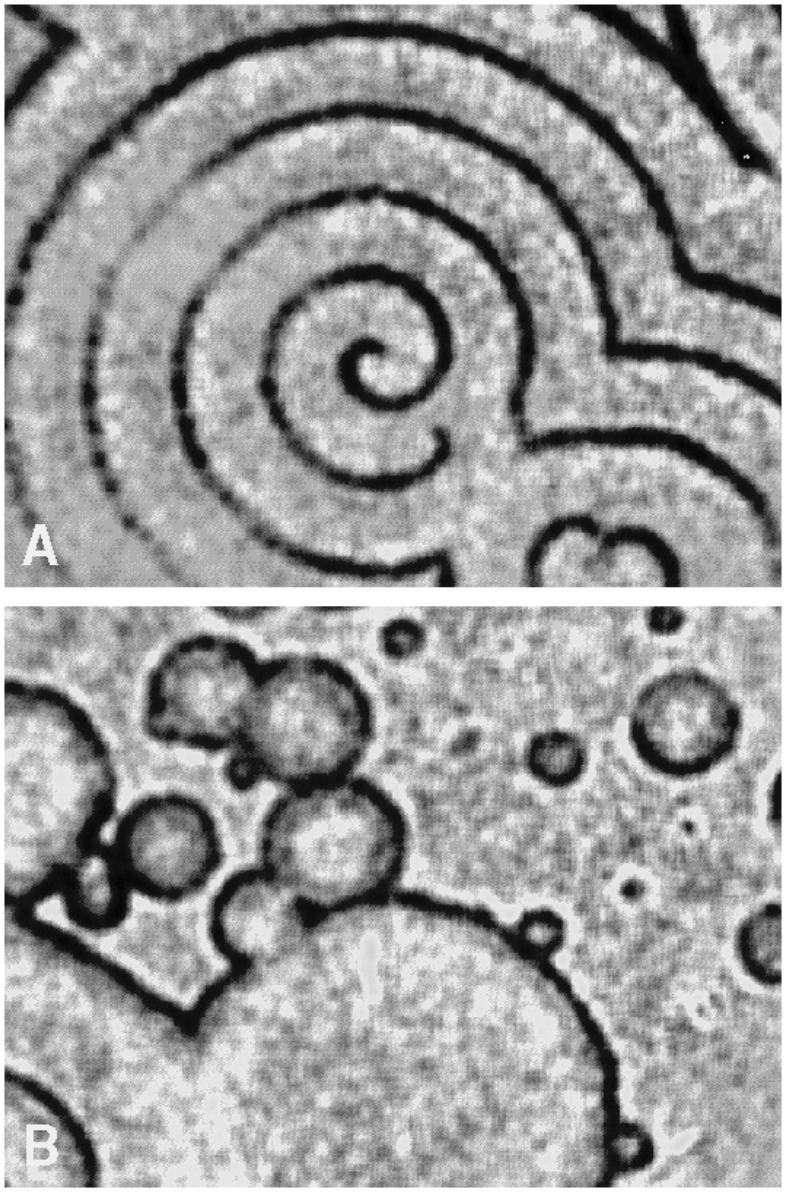


Lee, McCormick, Ouyang, and Swinney, 1993 (CIMA)

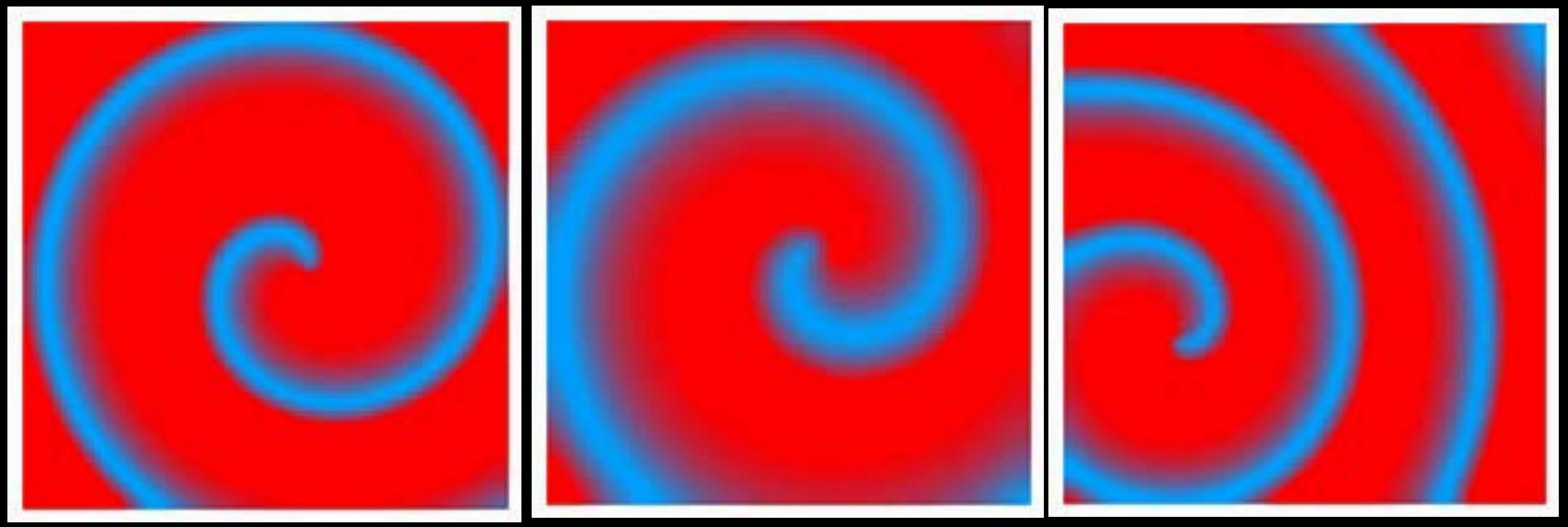
Dictyostelium discoideum



Chemical Waves



Spiral Waves in Theory



Back-of-the-envelope thinking

- Size of an atom (in ‘cgs’ units):

$$\mathcal{E} = \frac{\hbar^2}{2m}\frac{1}{\ell^2} - \frac{e^2}{\ell}$$

$$\frac{\partial \mathcal{E}}{\partial \ell} \rightarrow \frac{\hbar^2}{m\ell^3} = \frac{e^2}{\ell^2}$$

$$\ell = \frac{\hbar^2}{me^2} \simeq 0.05 \text{ nm}$$

$$\hbar = 10^{-27}\, erg\ s$$

$$m \sim 10^{-27}\, g$$

$$e \sim 5 \cdot 10^{-10}\, erg^{1/2} cm^{1/2}$$

- Calculate Energy using minimizer:

$$\mathcal{E}(\ell^*) = -\frac{me^4}{2\hbar^2} \simeq -13.6 \text{ eV}$$

No Laguerre polynomials needed…

The Viscous Regime