

Theoretical biological physics

Summer term 2016

Books:

Philips, Kondev & Thériot: Physical biology of the cell

Alberts et al: Molecular biology of the cell

Nelson: Biological physics

Schiessel: Biophysics for beginners

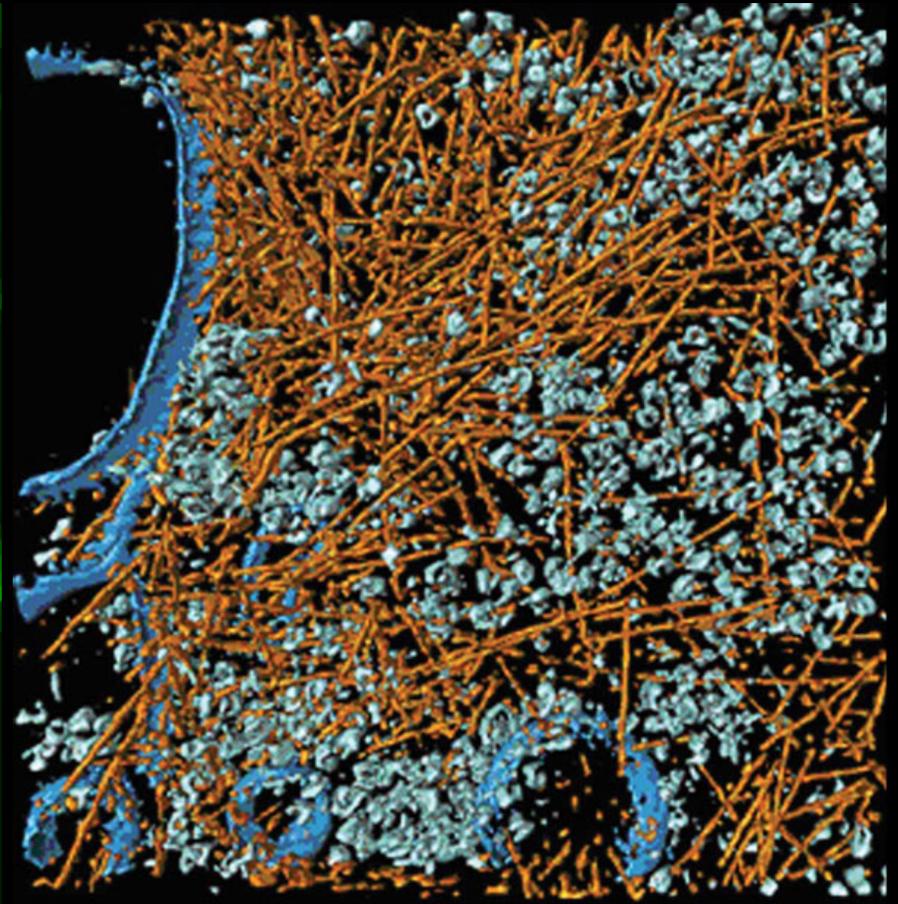
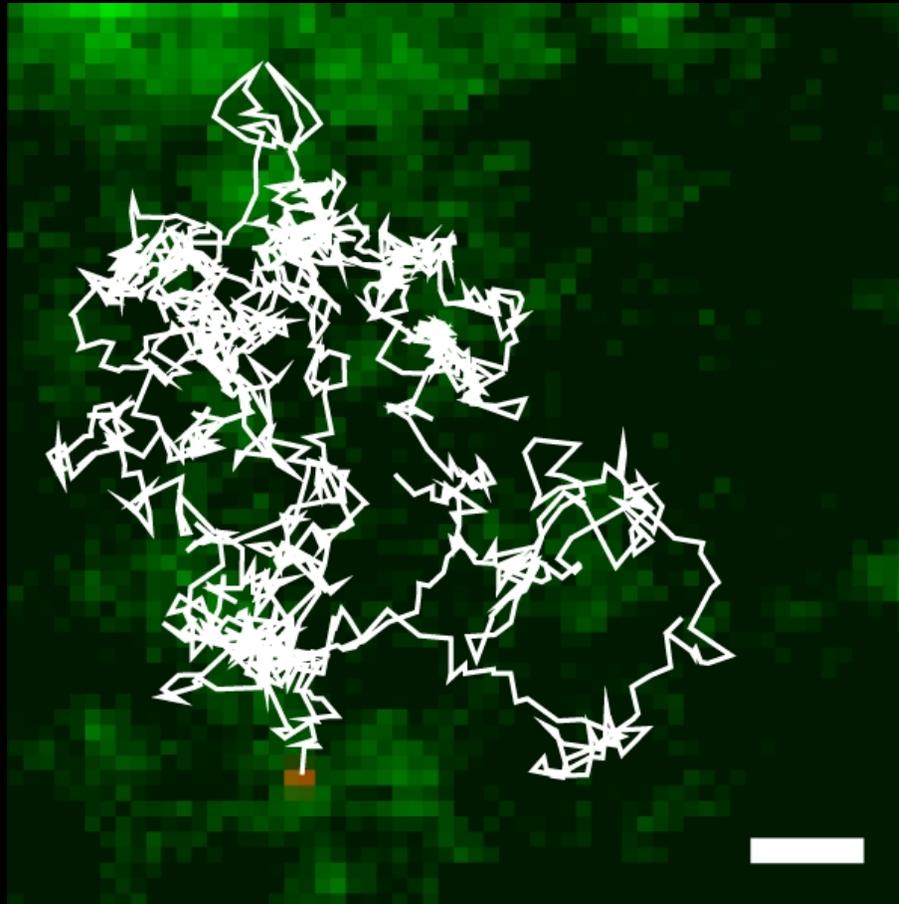
Blossey: Computational Biology

Bialek: Biophysics

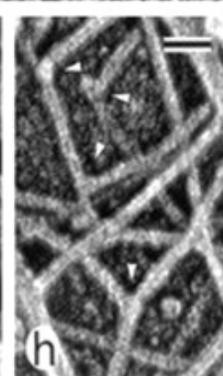
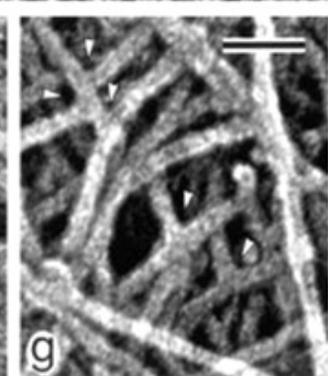
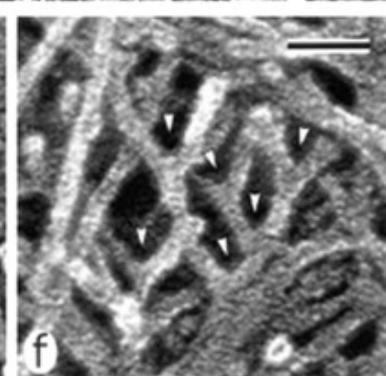
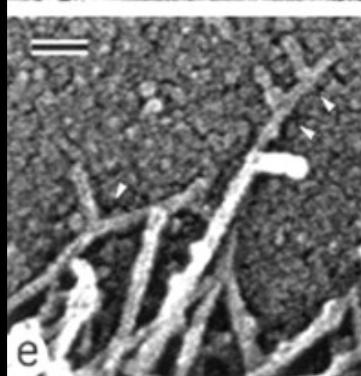
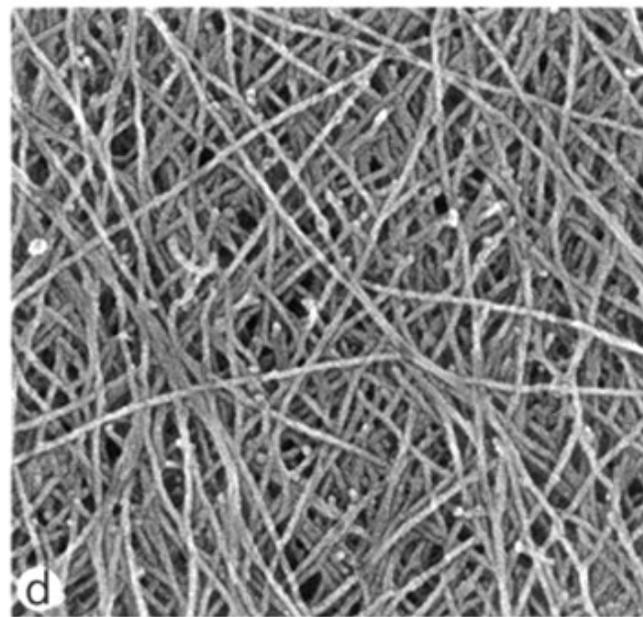
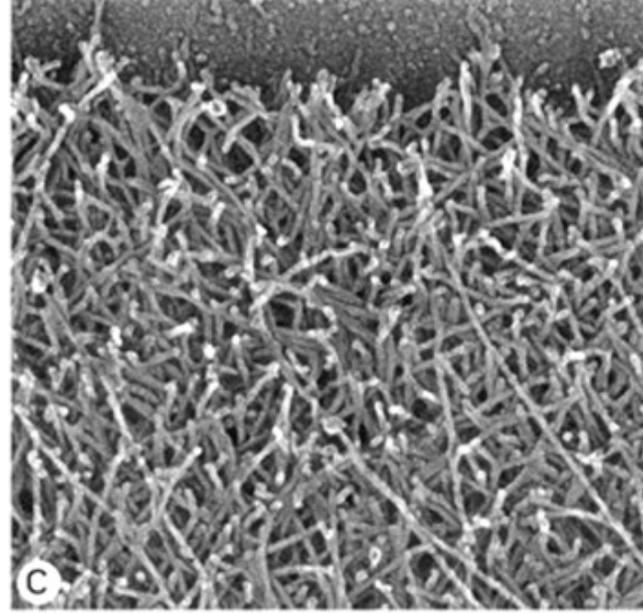
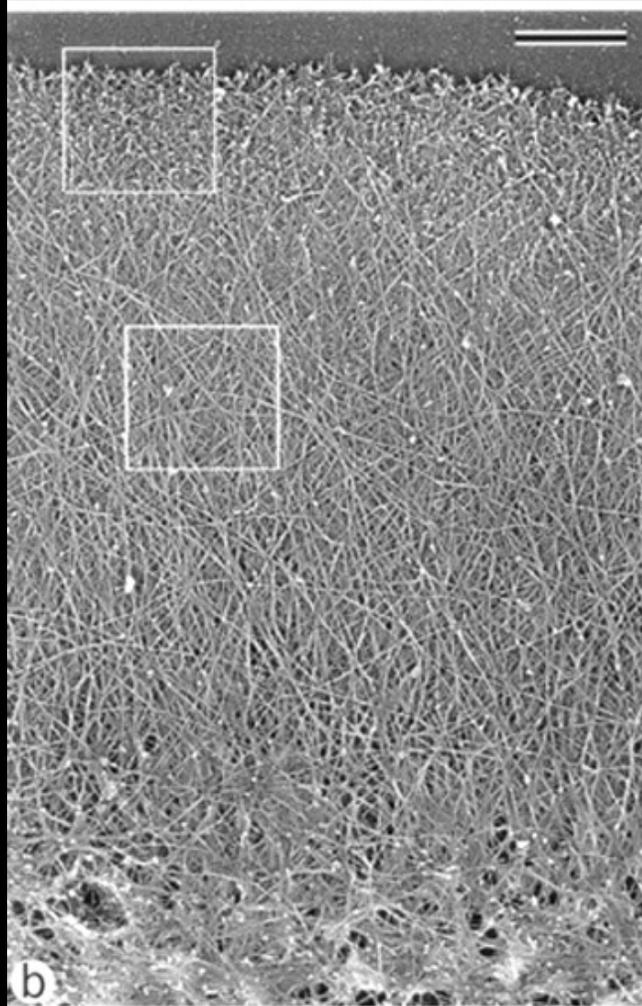
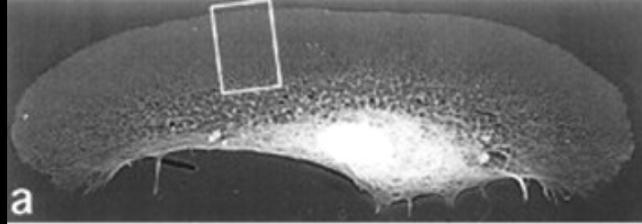
Topics: all things dynamic

1. **Passive and active transport**
2. **Biopolymers: DNA/RNA, proteins, filaments**
3. **Macromolecular crowding**
4. **Membranes**
5. **Motor transport**
6. **Genetic regulation in vitro & in vivo**
7. **Viral infection**
8. **Quorum sensing**

Experimental methods

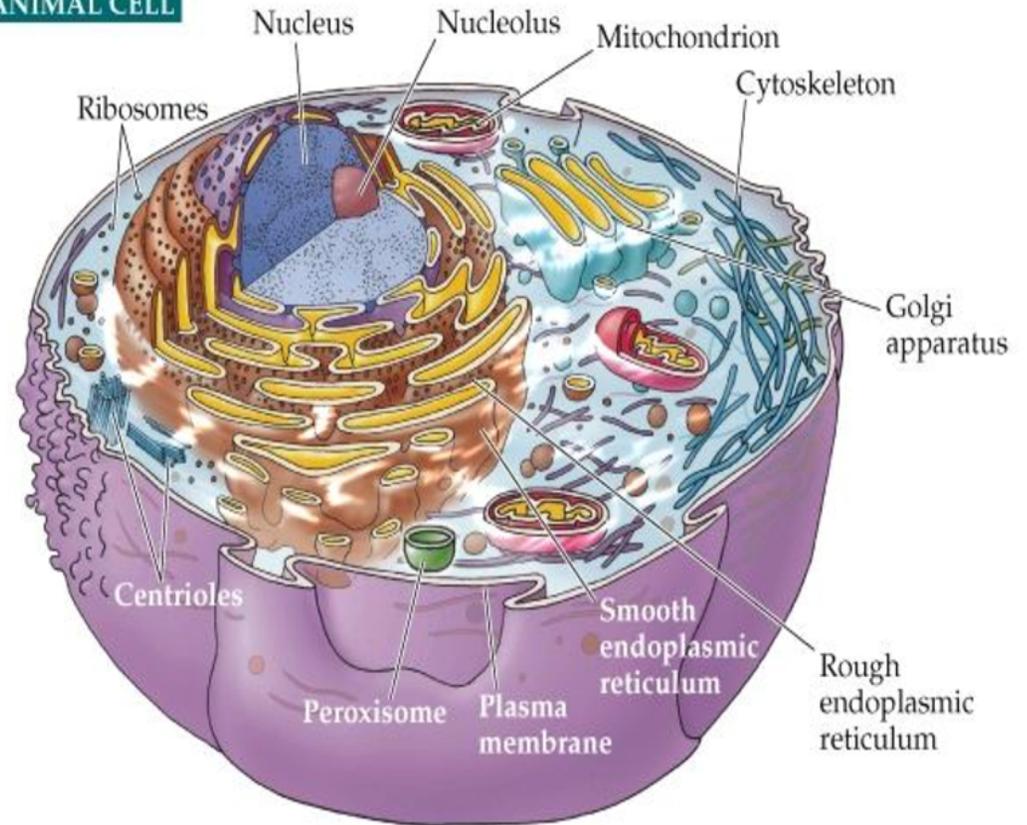
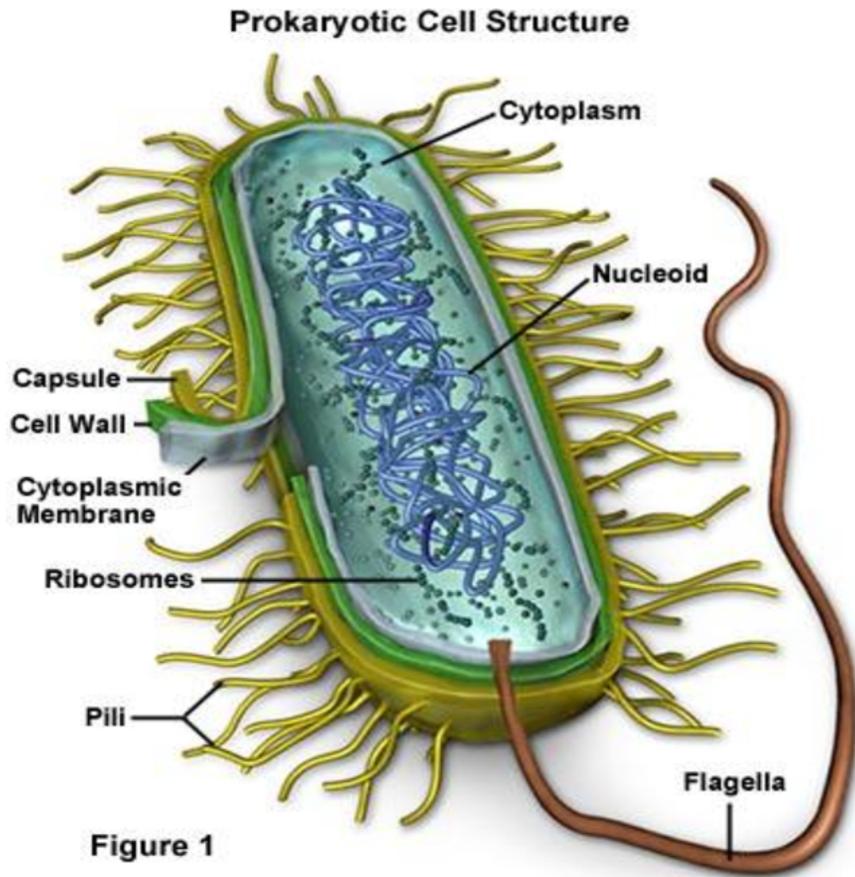


Courtesy D Krapf, Colorado State University; RJ Ellis & AP Minton, Nature (2003)

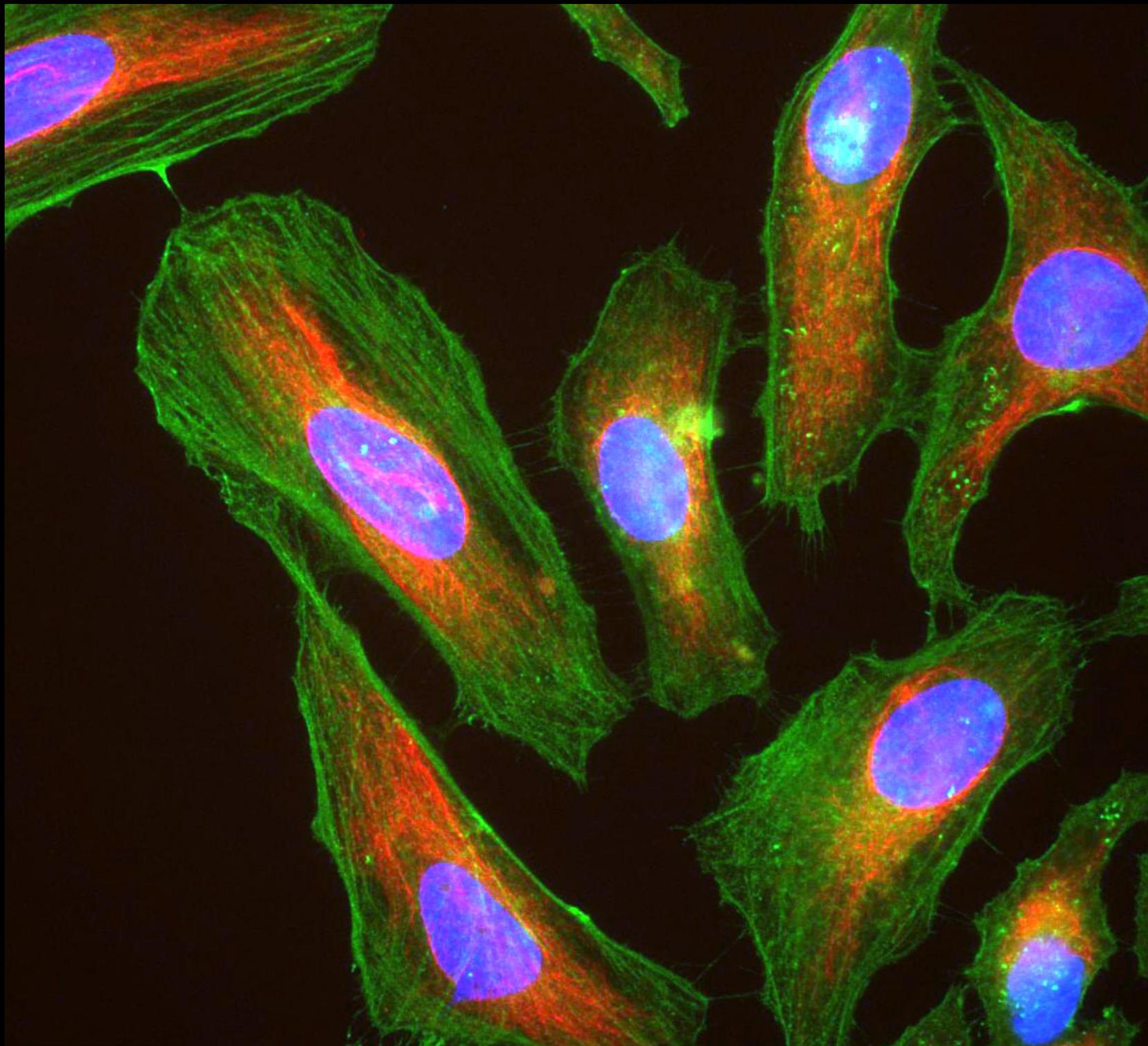


Prokaryotic vs Eukaryotic Cells

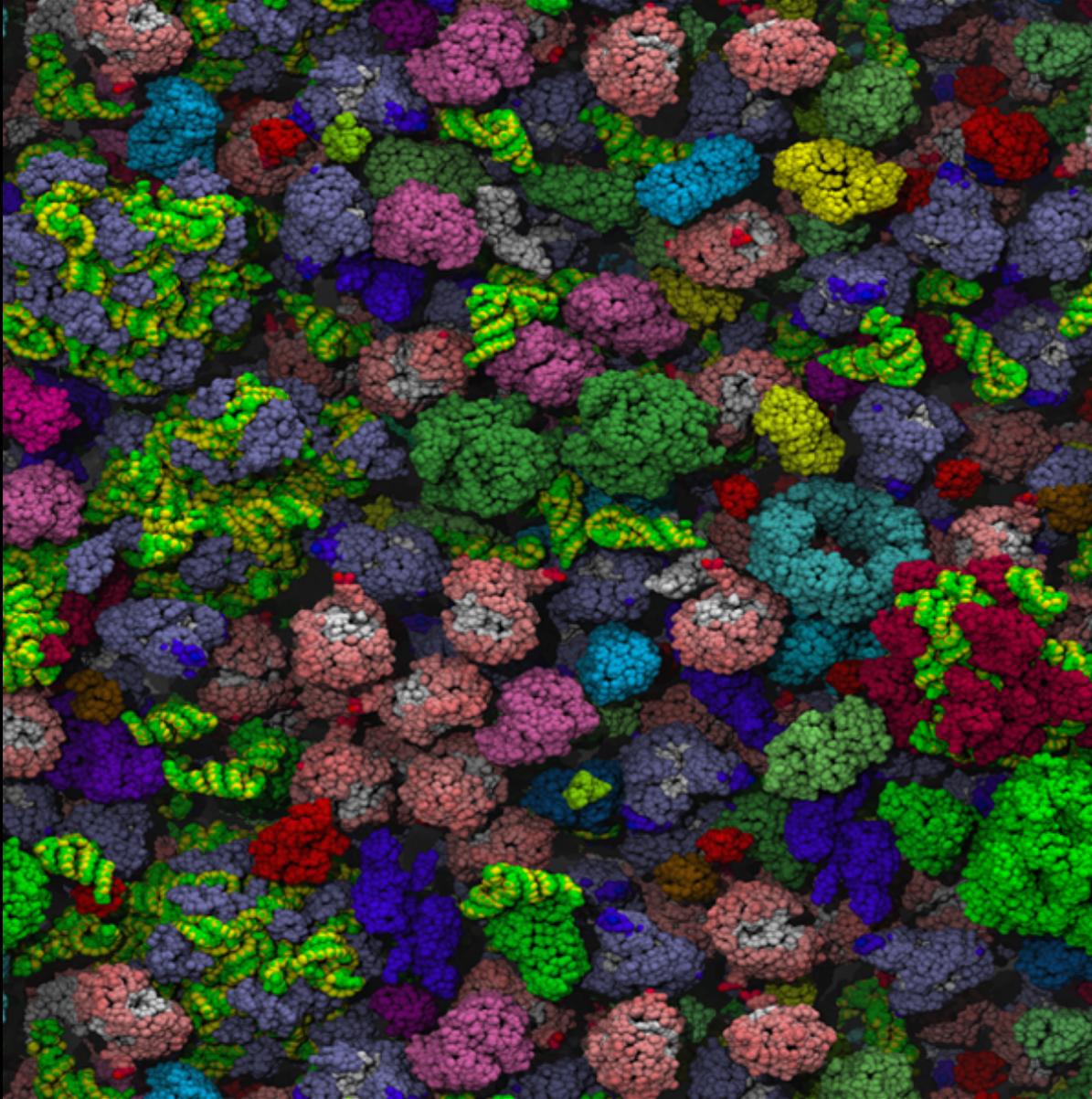
AN ANIMAL CELL



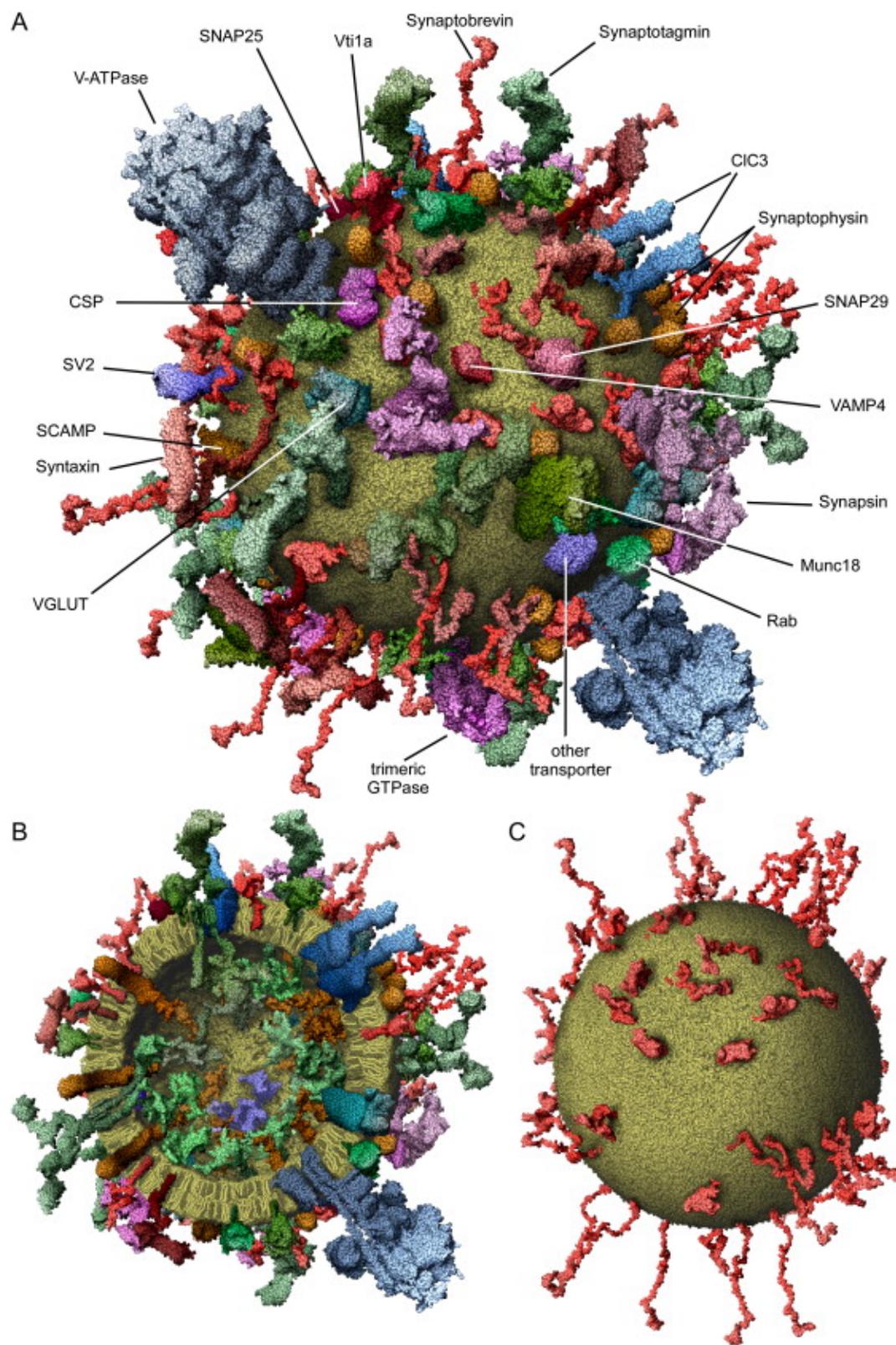
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Macromolecular crowding in living cells



SR McGuffee & AH Elcock, PLoS Comp Biol (2010)



Principles

I Complexity \longleftrightarrow compactification: crowding

II Information \longleftrightarrow entropy: life

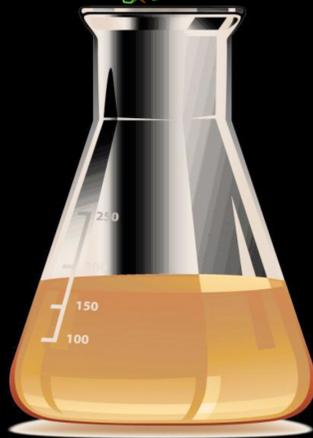
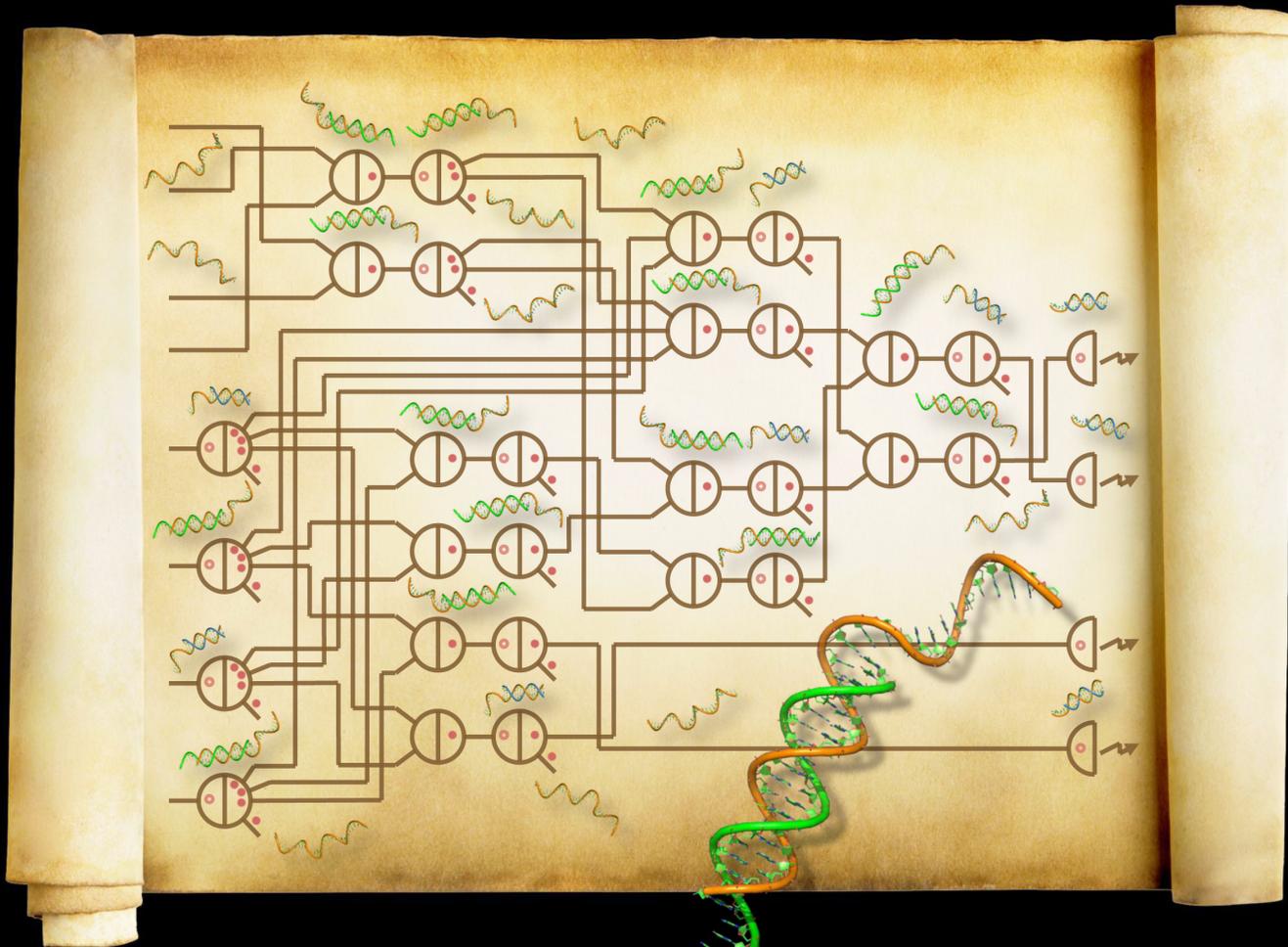
III Dynamics (non-equilibrium) & stochasticity \longleftrightarrow stability

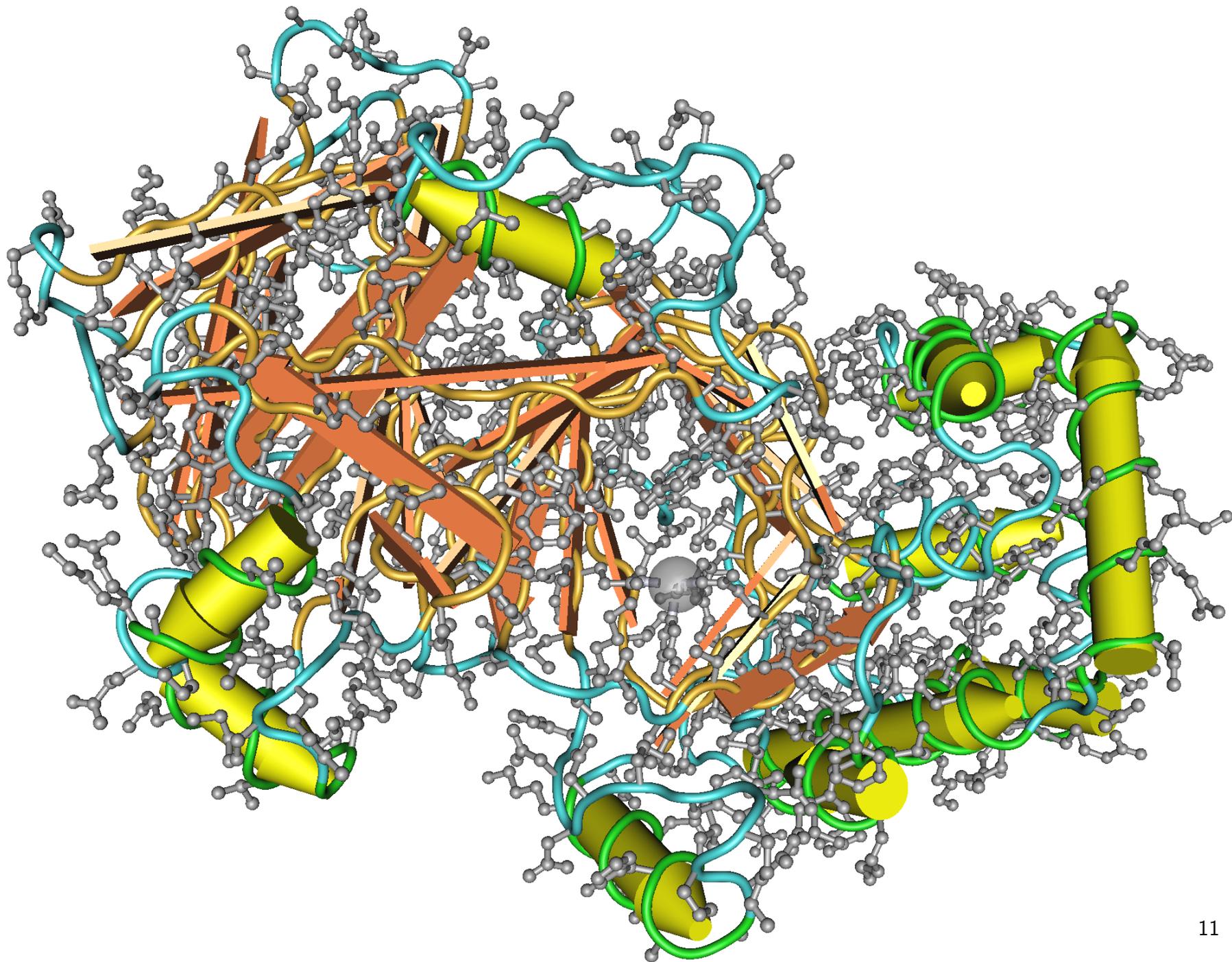
IIII Biochemical energy (activity) \longleftrightarrow free thermal energy $k_B T$

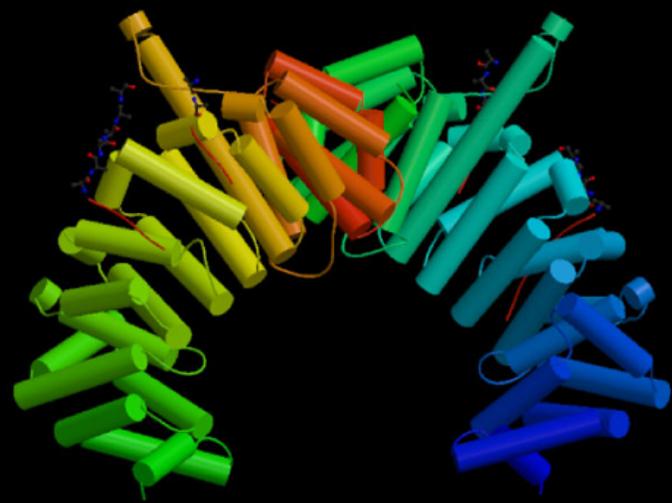
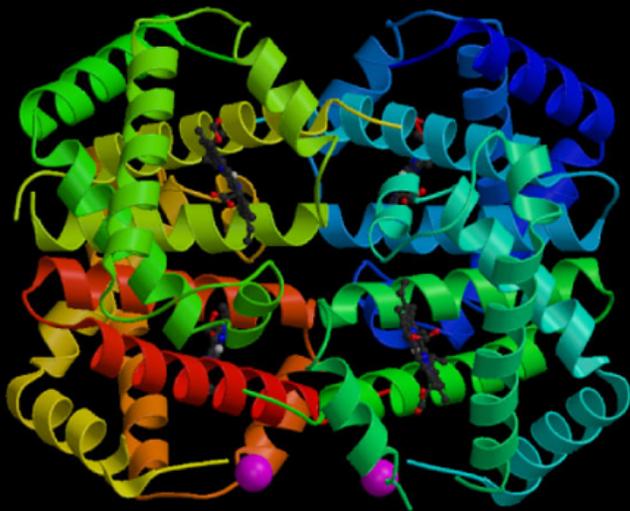
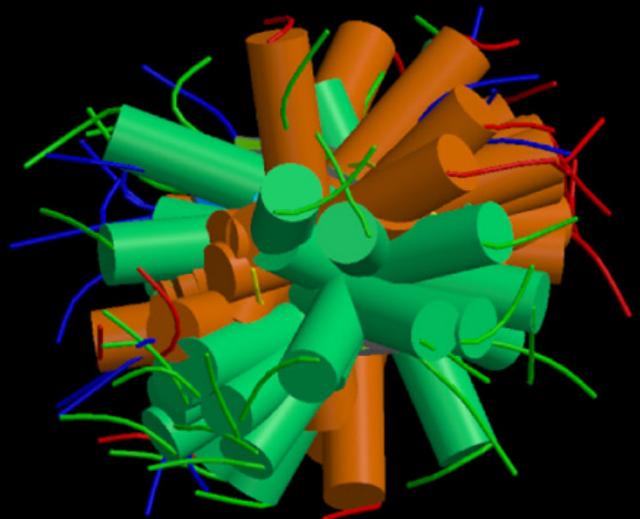
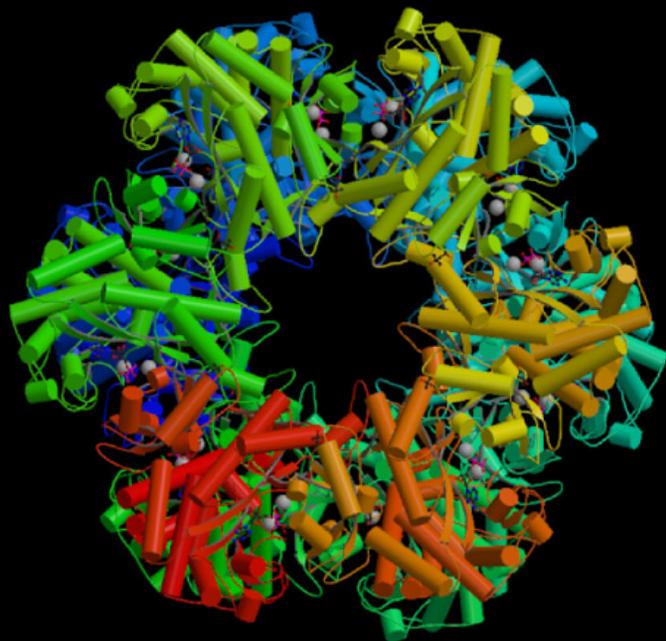
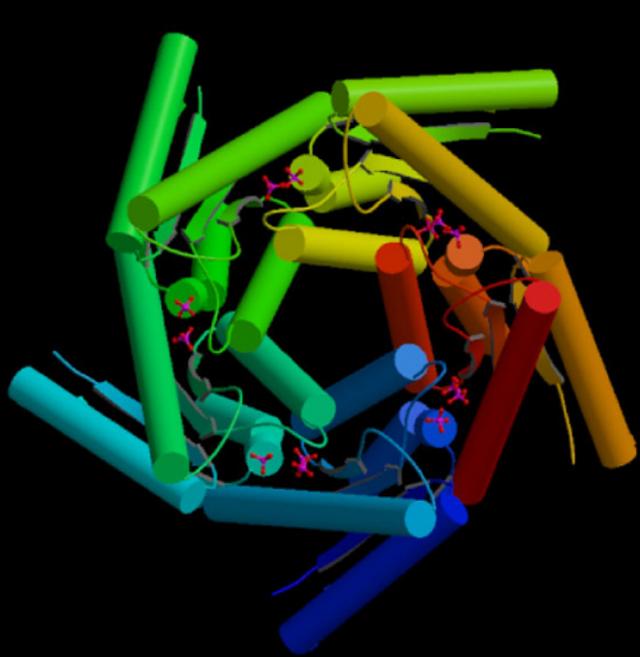
IIII Global \longleftrightarrow local

IIII| Coupling to extracellular world: communication, particle/energy fluxes, infection

IIII| Understanding: reductionist modelling; biophysics vs biological physics



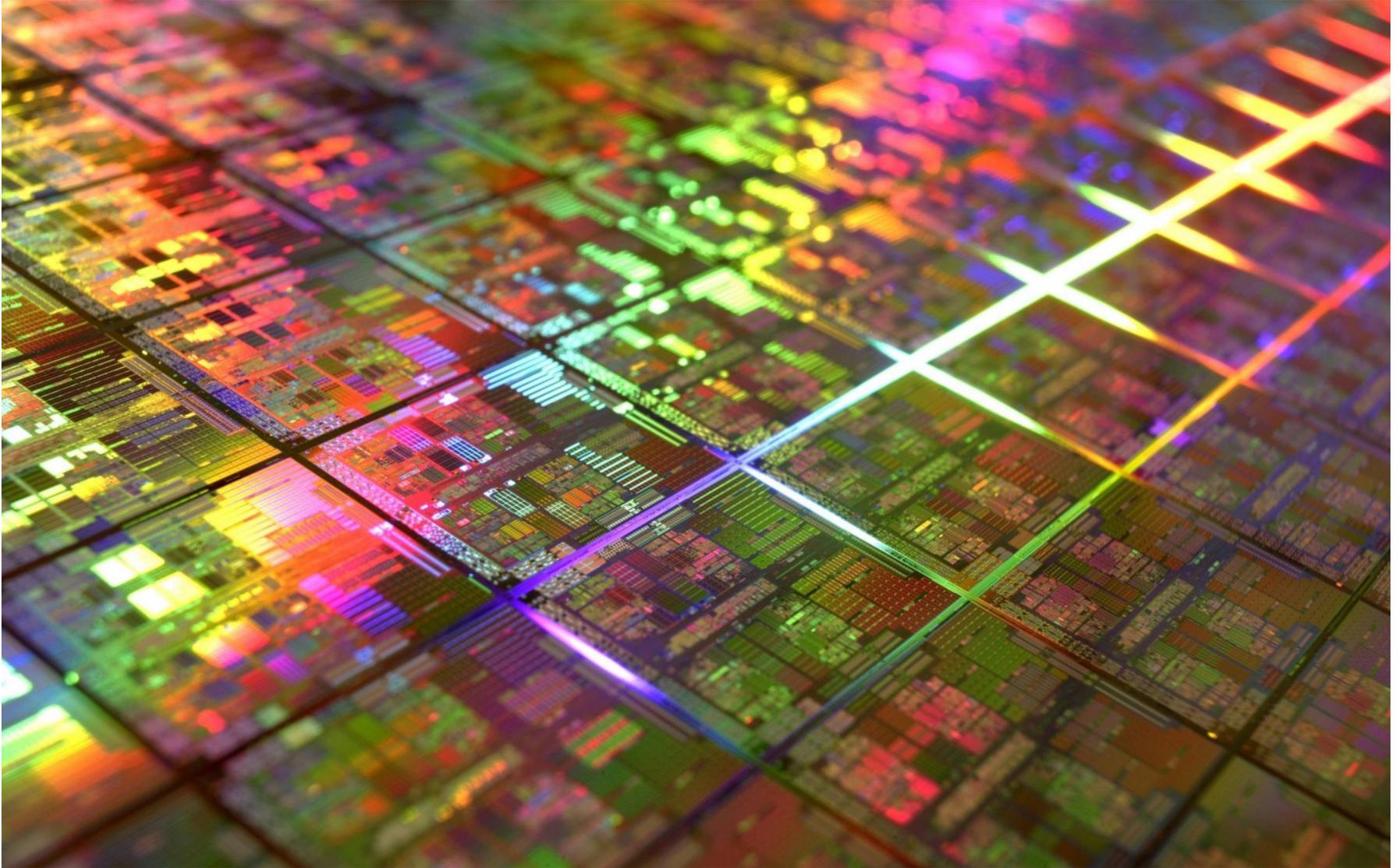




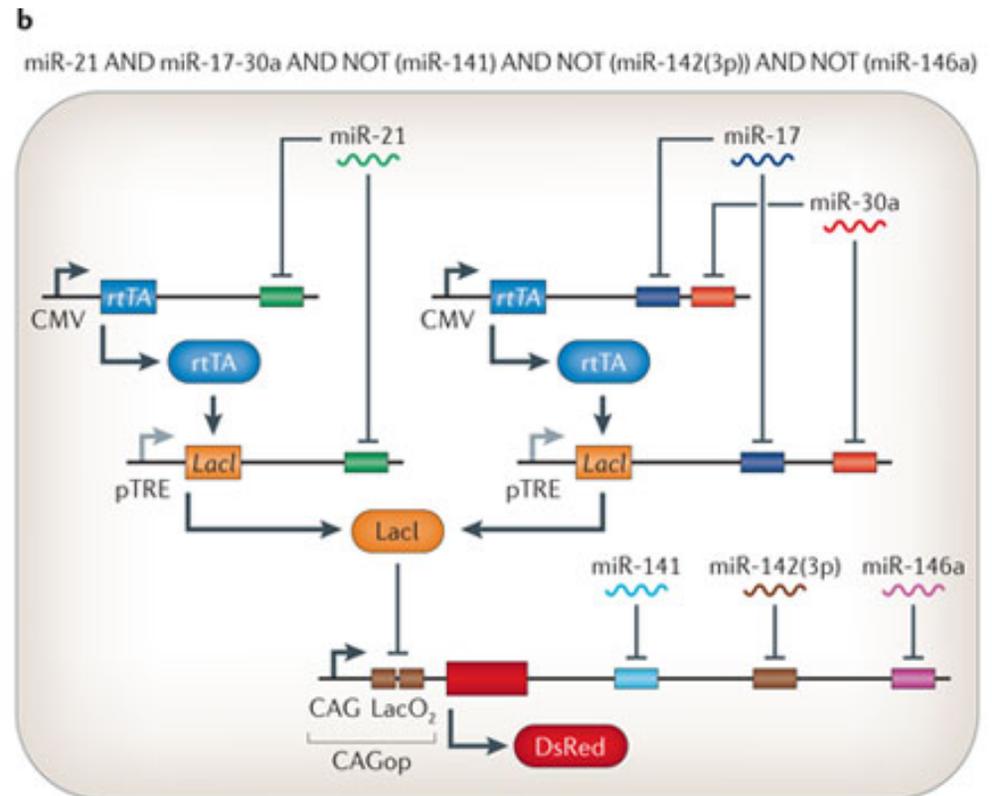
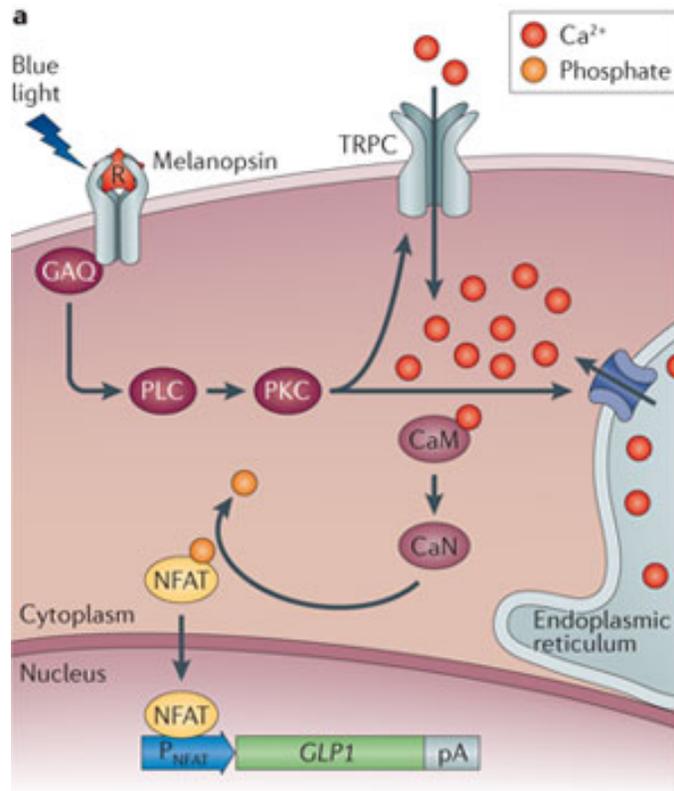
Ptashne slides

Ptashne & Gann, Genes & Signals

Regular computing



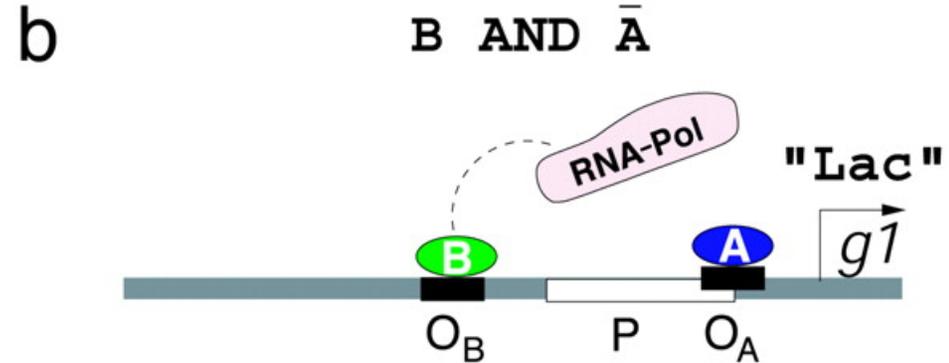
Cellular computing



Combinatorial transcription logic

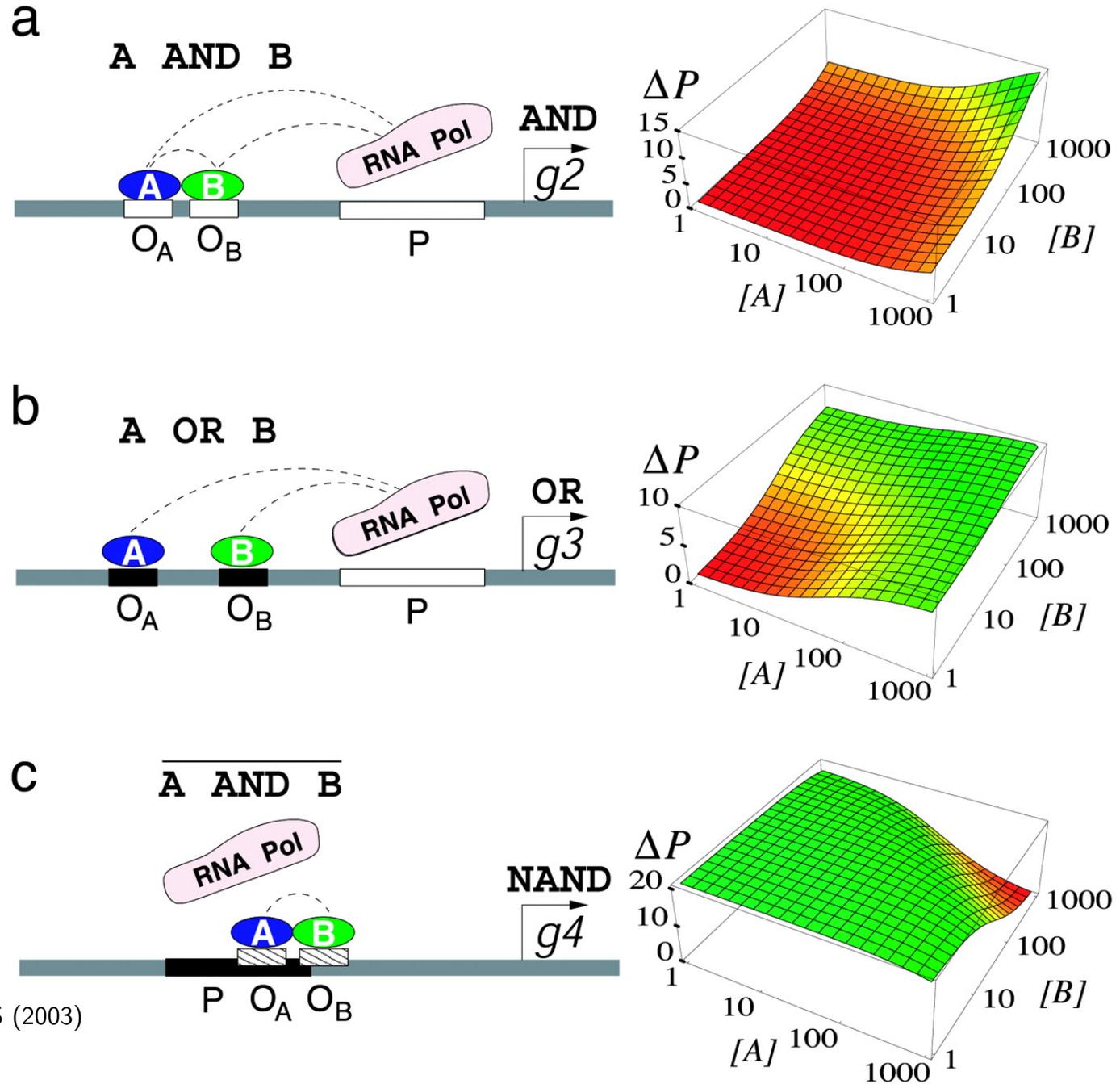
a

	"Lac"	AND	OR	NAND	XOR	EQ	
A	B	<i>g1</i>	<i>g2</i>	<i>g3</i>	<i>g4</i>	<i>g5</i>	<i>g6</i>
low	low	OFF	OFF	OFF	ON	OFF	ON
high	low	OFF	OFF	ON	ON	ON	OFF
low	high	ON	OFF	ON	ON	ON	OFF
high	high	OFF	ON	ON	OFF	OFF	ON



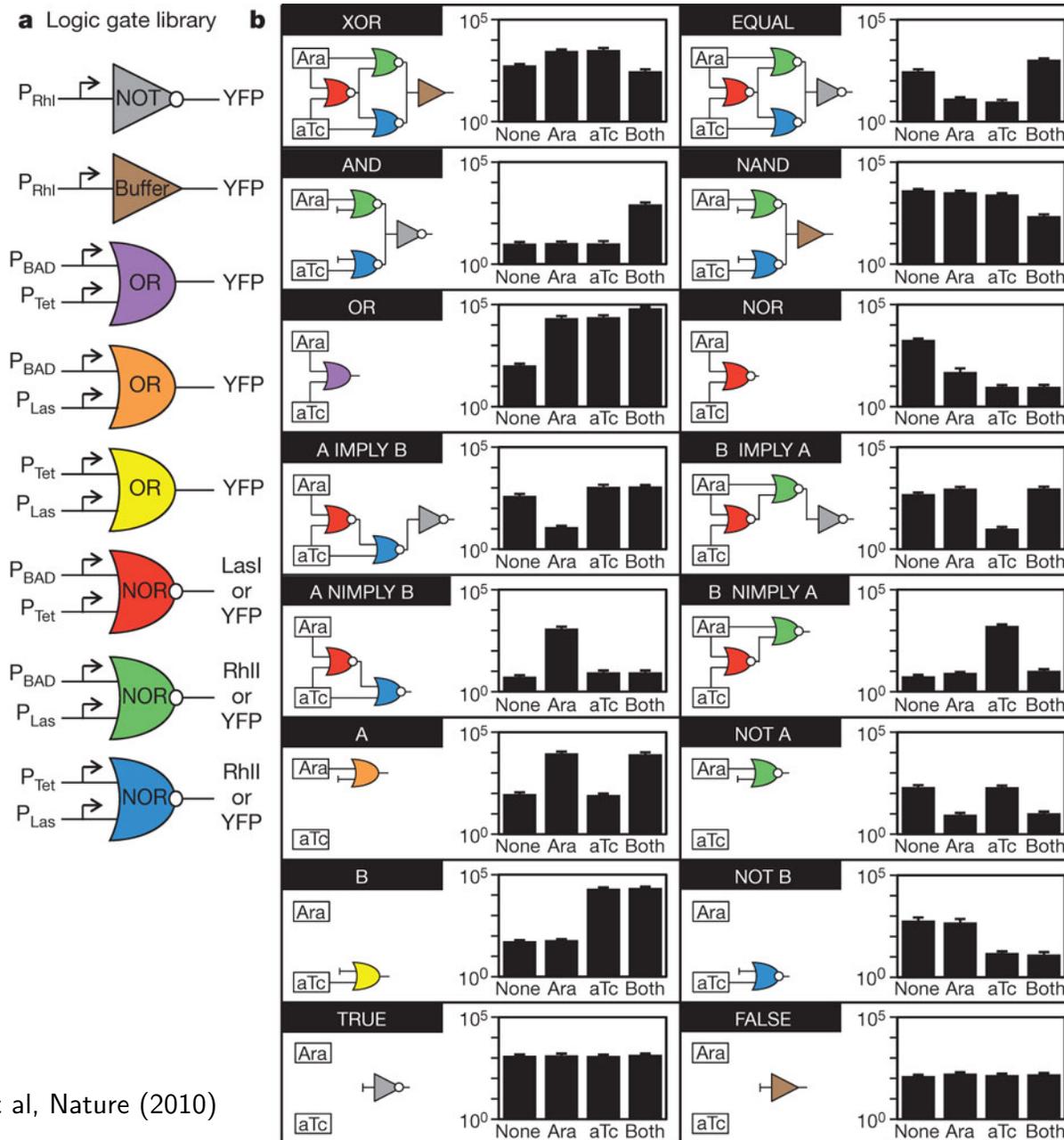
- I Biocomputer based on continuous regulation & gene expression
- II Delay times on the range of many sec
- III Readout eg by production of fluorescent proteins
- IIII Could nicely act as intelligent biosensor for multiple substances etc

Combinatorial transcription logic



Buchler et al, PNAS (2003)

Logic gates in *Escherichia coli*



Human protein network

