# Randomness and information in biological data
# BIO-369

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EPFL

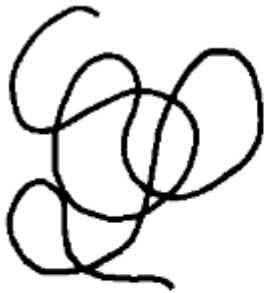
Lecture 4

# Outline of the course

# Reminder: flexibility of biopolymers

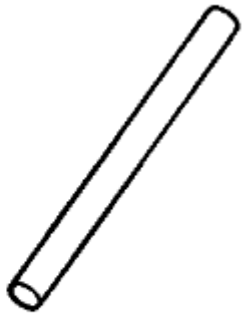
- **Persistence length**

(a): total length >> persistence length



(a)

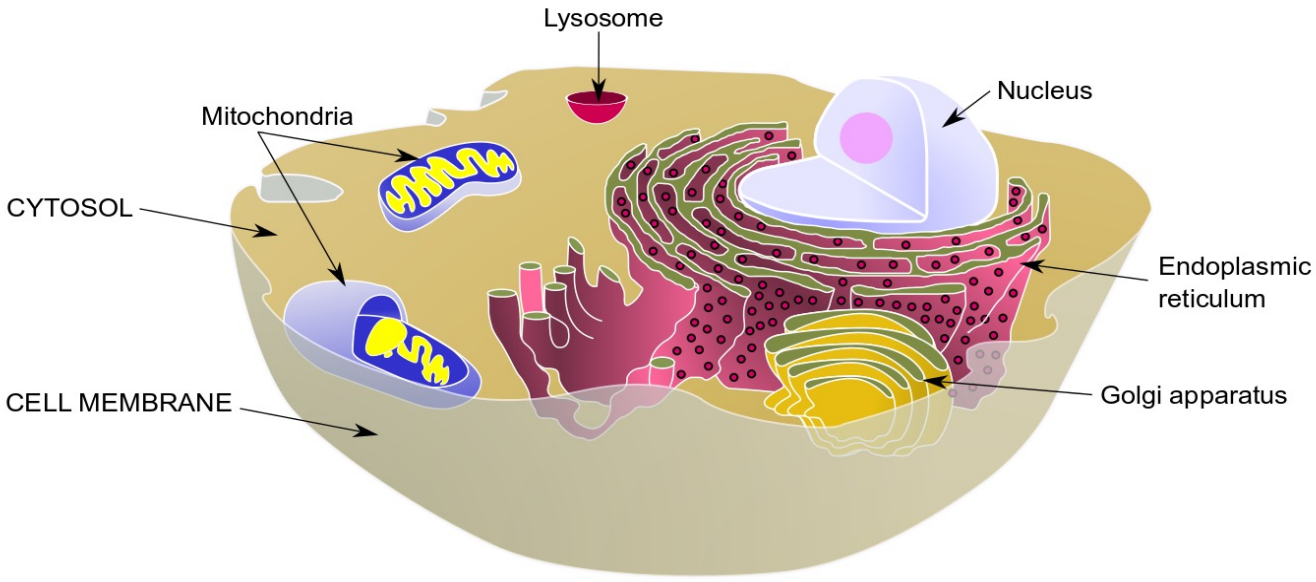
(b) total length << persistence length

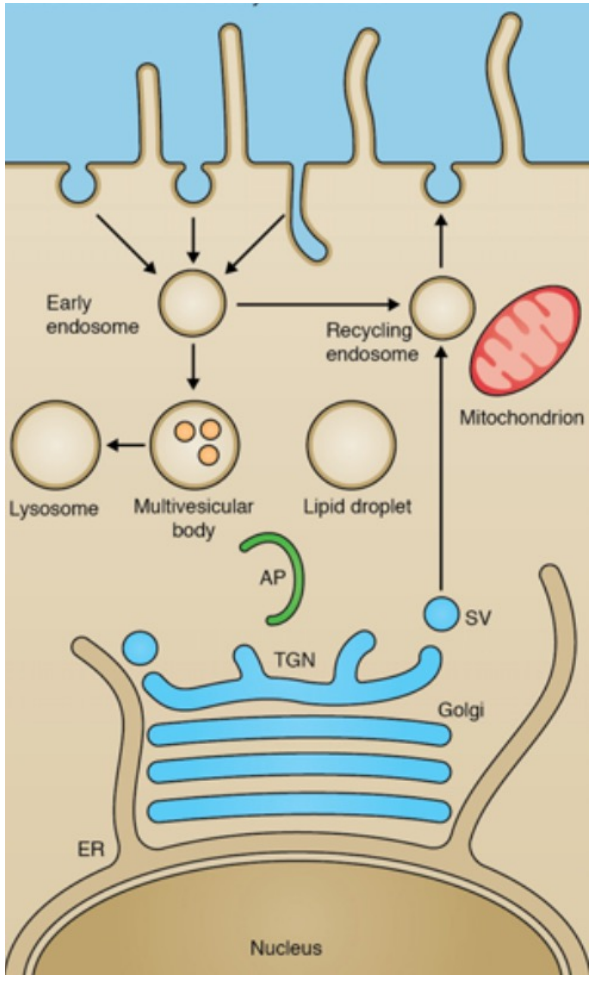


(b)

# Biomembranes: motivation

- **Biomembranes are curved and constantly change shape**



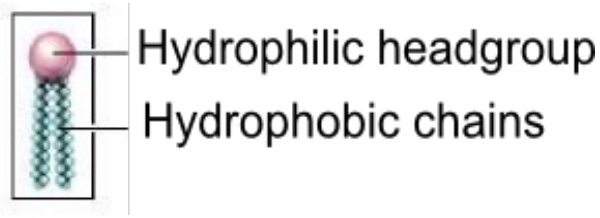




Membrane thickness: a few nm
Cell size: 1 – 100 μm

# Biomembrane properties

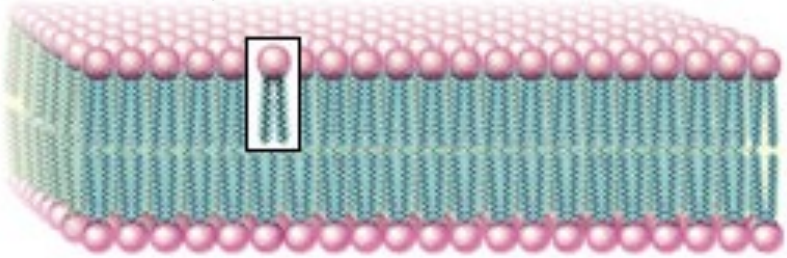
- **Basic structure**

Lipid molecule: amphiphilic

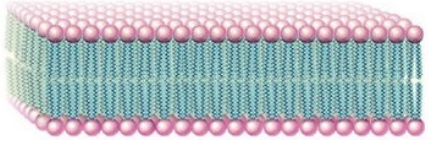


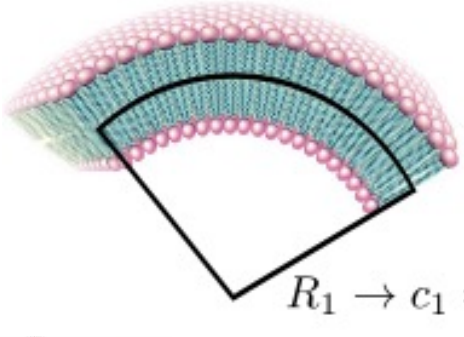

Self-assembly in water

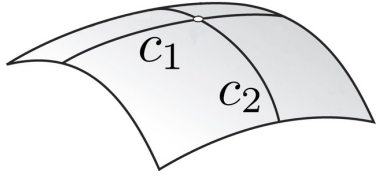
Lipid bilayer



- **Elasticity: bending**





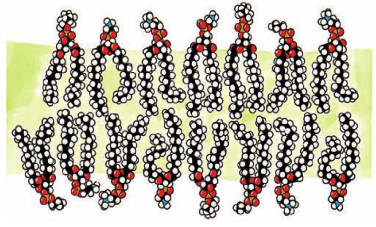




Curvature energy:

$$H = \int_A dA \, \frac{\kappa}{2} (c_1 + c_2)^2$$

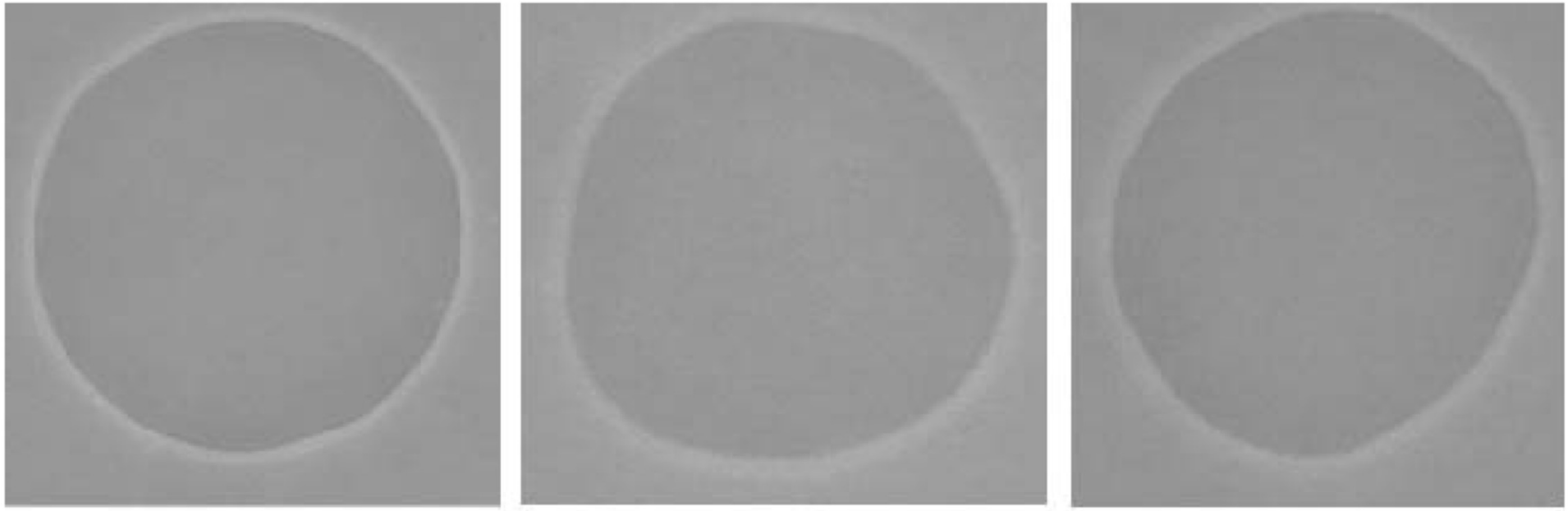
Helfrich (1973)

- **Fluidity**



Each monolayer is a 2D fluid

# Flexibility of biomembranes



Snapshots of a giant unilamellar vesicle (i.e., a closed bilayer of lipids in water) of diameter 50 μm observed under the microscope at different times

# Conclusion

- Thermal fluctuations have a strong impact at the microscopic scale, esp. at the cellular scale

- Importance of comparing the energy scales involved in important cell biology processes to the energy scale $k_B T$ of thermal fluctuations (Boltzmann distribution)

- Many cell biology processes, including DNA base pairing, protein-protein interactions, biopolymer and biomembrane deformations, involve energies larger than $k_B T$, but not by a lot, typically of order 10 to 20 $k_B T \rightarrow$ stable to thermal fluctuations but readily deformable

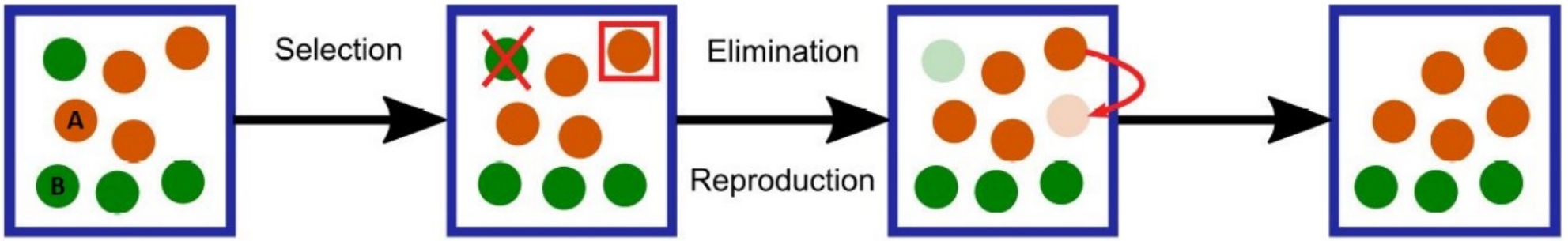
- In particular, can be deformed by active processes involving ATP consumption:
  Hydrolysis of ATP to ADP releases an energy of 30 kJ/mol, thus for the hydrolysis of one molecule of ATP:

$$\Delta E_{\mathrm{ATP}} \approx 12\, k_{\mathrm{B}} T$$

# Outline of the course

# Random walks

- **The Moran model in population genetics**




Schematic of one step of the Moran process
The population comprises two types of individuals, type A (orange) and type B (green)

Upon one step of the Moran process, involving one birth and one death, how can the number i of mutants possibly vary?

A. It depends on fitnesses: if the mutant is fitter than the wild-type, i will increase
B. It can increase or decrease by up to N, or stay constant
C. It can increase or decrease by up to N, but not stay constant
D. It can increase or decrease by 1, or stay constant
E. It can increase or decrease by 1, but not stay constant

To answer, please:

- Connect to http://ttpoll.eu
- Enter the session ID **bio369**
- Select your answer

Assuming that we start from one mutant (i=1) among N individuals, and that there are no new mutations, what are the possible states of the population after a very large number of steps of the Moran process?

A. The wild type will take over and the mutant will disappear
B. The mutant will take over and the wild type will disappear
C. Answer A if the wild type is fitter, answer B if the mutant is fitter
D. The two types will coexist forever
E. It depends – A, B and D can all happen
F. It depends – A and B can happen, but D cannot happen

To answer, please:

- Connect to http://ttpoll.eu
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- Select your answer

Assuming that we start from no mutant (i=0) among N individuals, and that there are no new mutations, what is the probability of fixation of the mutant type?

A. 0
B. 1
C. 1/N
D. It depends on fitnesses and on N

To answer, please:

- Connect to http://ttpoll.eu
- Enter the session ID **bio369**
- Select your answer

Assuming that we start from one **neutral** mutant (i=1) among N individuals, what is the probability of fixation of the mutant type in the population?

A. 0
B. 1
C. 1/N
D. It depends

To answer, please:

- Connect to http://ttpoll.eu
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- Select your answer