TIME-DEPENDENT MECHANICAL RESPONSE OF THE CYTOSKELETON

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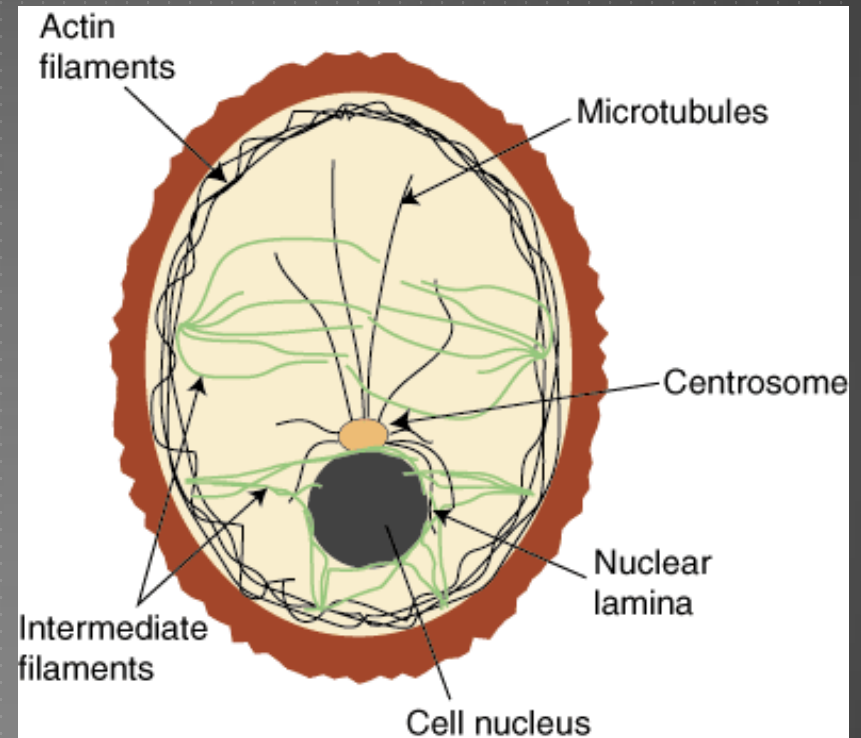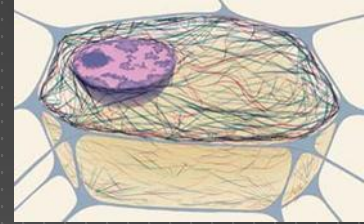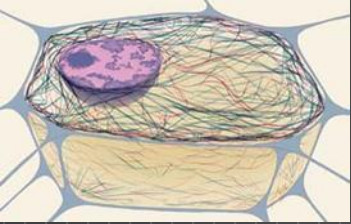
SESAPS 2011

CONTENTS:

- Cytoskeleton(CSK)
- Motivation
- The Model
- Results

Actin filaments
Microtubules
Centrosome
Nuclear lamina
Cell nucleus
Intermediate filaments

PROPERTIES OF PROTEIN FILAMENTS
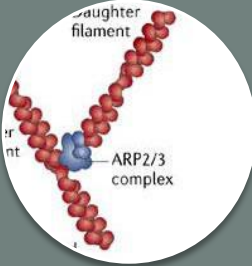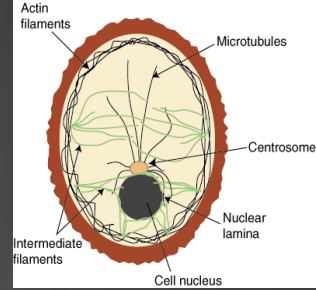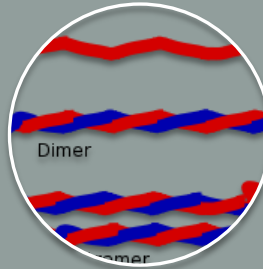

Actin
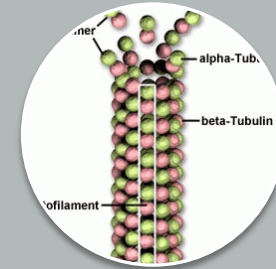Diameter=$6nm$
Pers. Length=3-$10\mu m$
Double helix

Intermediate filament
Diameter=8-$10nm$
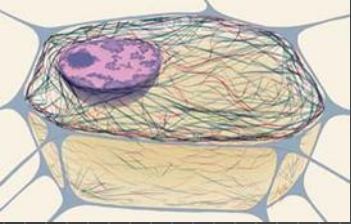Pers. Length= 0.3-$1\mu m$
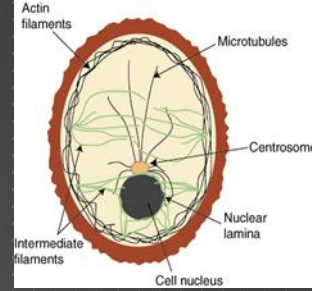2 antiparallel helix

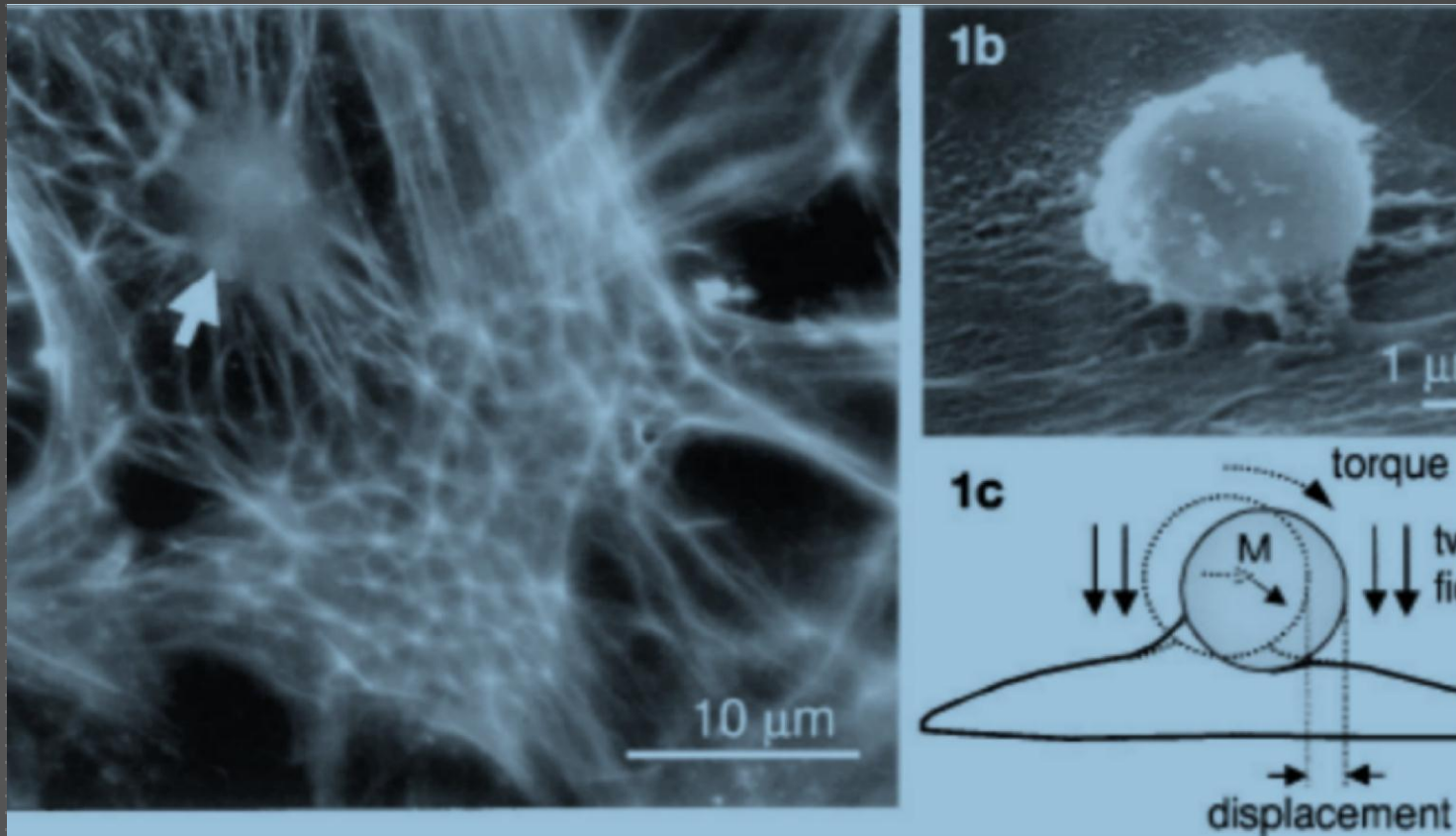Microtubule
Diameter=$23nm$
Pers. Length=1-$8mm$
Hollow cylinder

CSK ROLL IN THE CELL
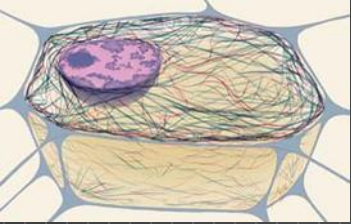
- Establishing cell shape
- Providing mechanical strength
- Locomotion
- Chromosome separation in mitoses and meiosis
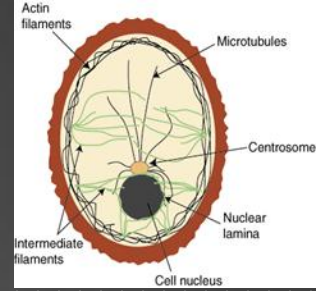- Cellular division
- Intracellular transport of organelles

MOTIVATION
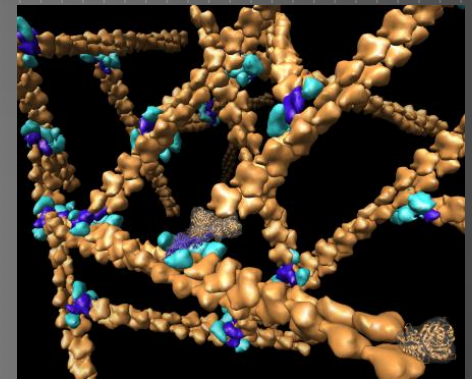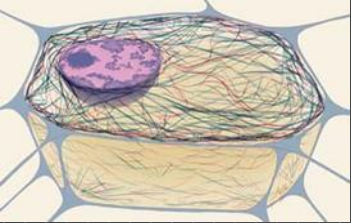

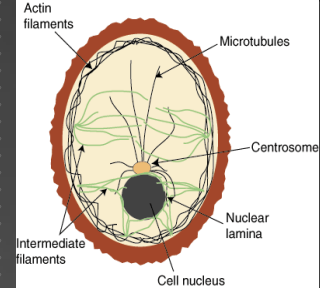B. Fabry et al,. Phys. Rev. Lett. 87, 148102 (2001)

COMPUTATIONAL MODEL

▶ 3D model of actin network

▶ Periodic and Free boundary conditions

▶ Create the network out of equilibrium

▶ Relax by Monte Carlo movements

▶ Perturb the cell

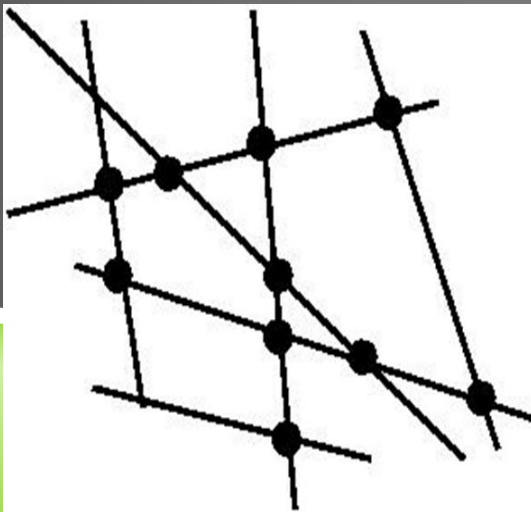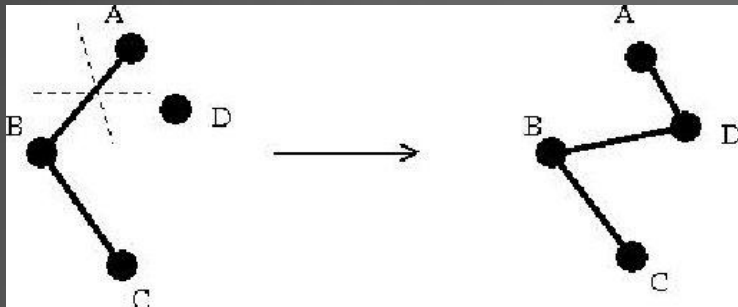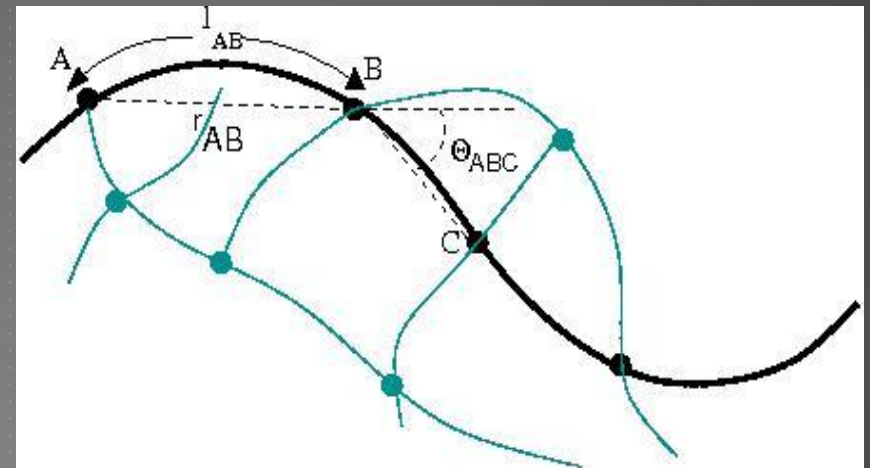E.M Huisman et al.,Phys. Rev. E 78, 051801 (2008)
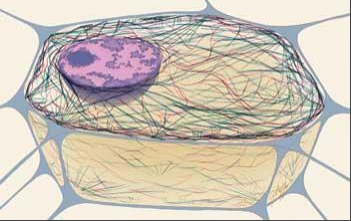
INITIAL STEPS OF THE MODEL

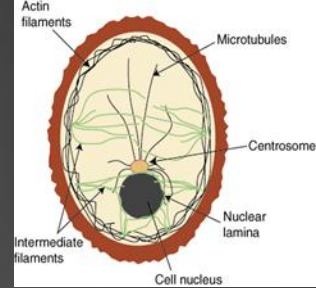▶ Creation of four fold connected network

▶ Assign polymer length for each segment

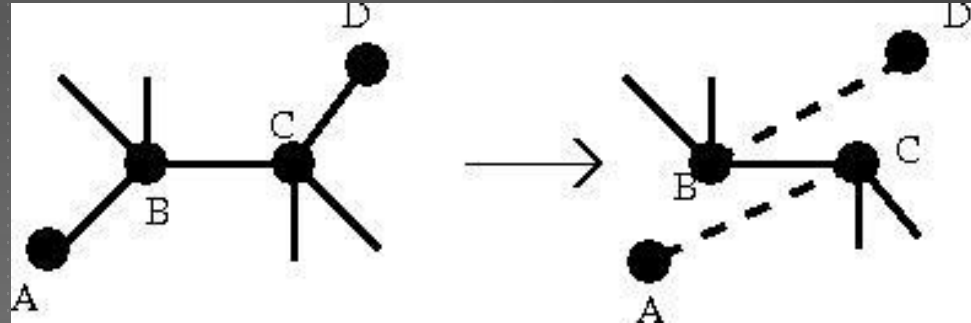J. Wilhelm and E. Frey, PRL(**77**) 2581 (1996)

ENERGY OF THE SYSTEM

▶ Energy is sum over all the segments energy,

$$\frac{E}{k_B T} = \sum_i \frac{\mu}{2}\left(r_i - r_{0,i}\right)^2 + \sum_{i,j} \frac{l_p}{l_{c,i} + l_{c,j}} \theta_{i,j}^2$$

▶ μ: Stretching Coefficient

▶ r_i : End to end length

▶ $r_{0,i}$: End to end equilibrium length

▶ l_p : Persistence Length of the filament

▶ $l_{c,i}$: Polymer length
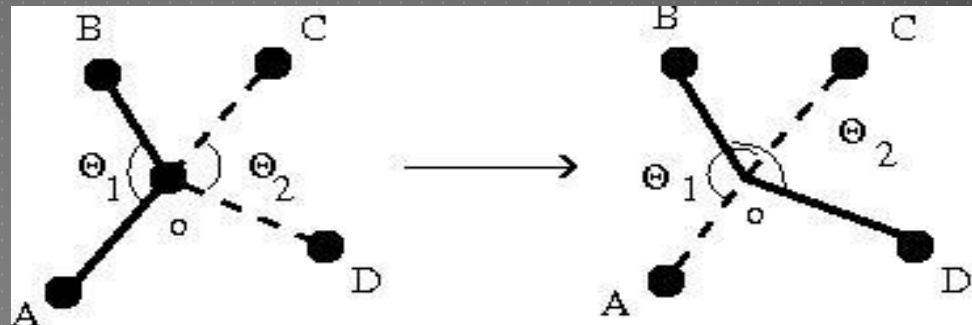
▶ $\theta_{i,j}$: Angle between segment i and j
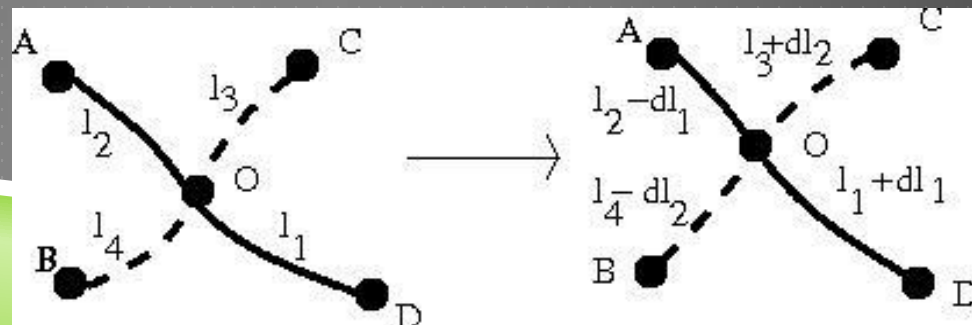
RELAX THE SYSTEM BY MONTE CARLO MOVES

▶ Rewiring
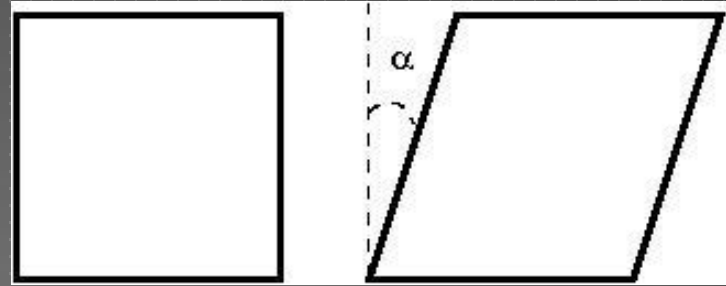
Chop entangled initial filament

▶ Relabeling

▶ Shifting Nodes

CELL PERTURBATION AND AUTO CORRELATION

▶ Shear the cell,

▶ Two step relaxation
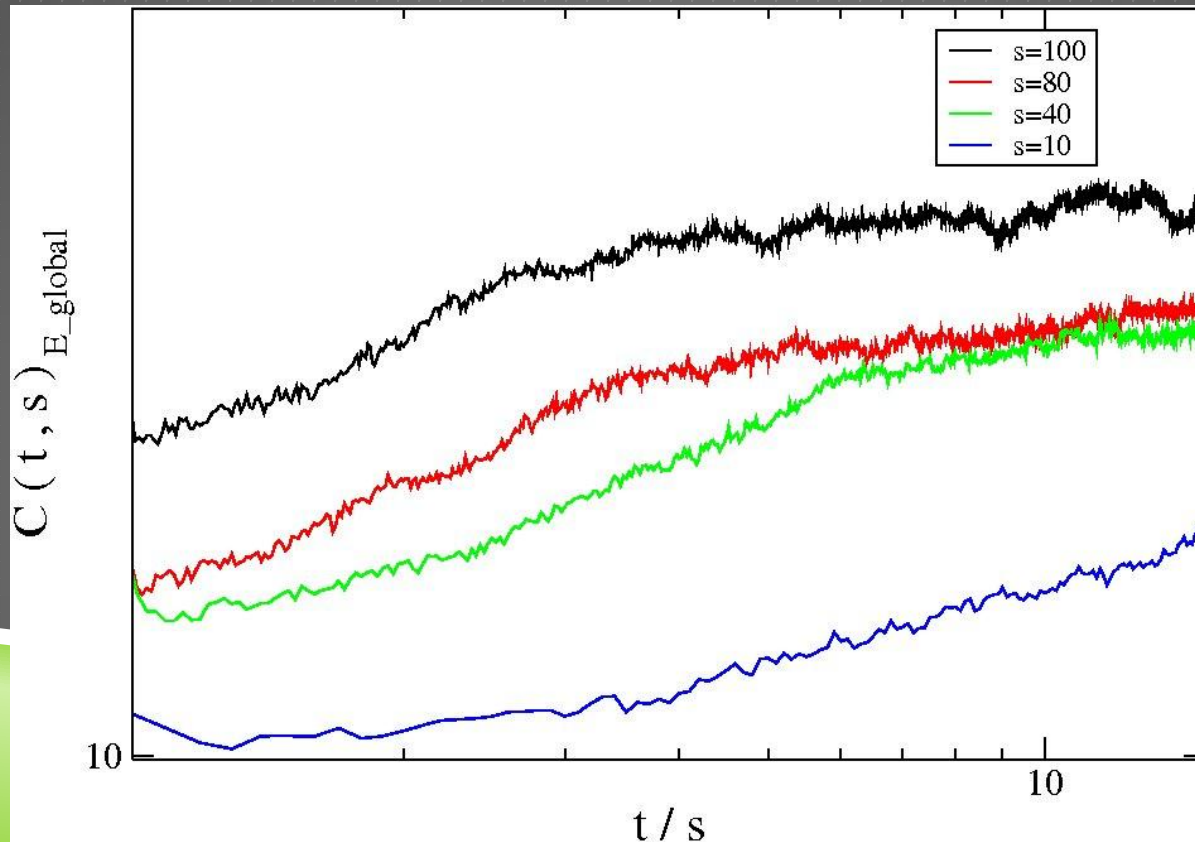
$$C(t,s)_{ED} = < L(t)L(s) > - < L(t) >< L(s) >$$
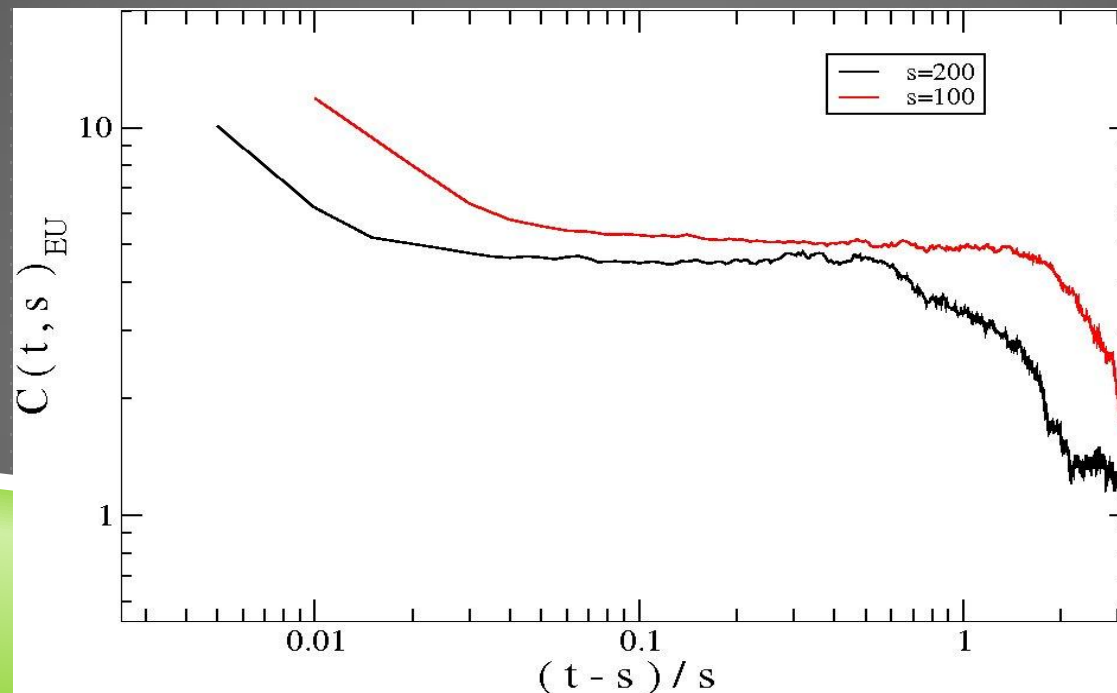
AUTO CORRELATION FUNCTION

▶ Global Energy

$$C(t, s)_{E_{glob}} = < E(t) E(s) > - < E(t) > < E(s) >$$

FUTURE PLANS
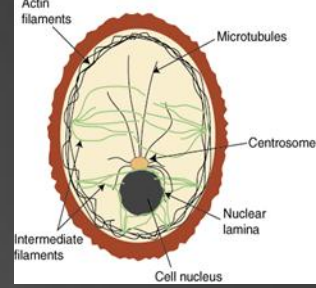
▶ Look at the response of the system

▶ Study the role of the membrane

▶ Add flexible crosslinks

▶ Add entanglement points for each segment

Thank You