Noguchi Group

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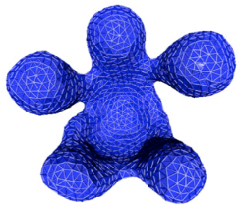
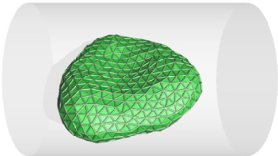


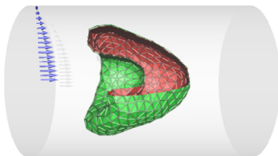
We study soft-matter physics and biophysics theoretically and numerically. Our main target is physics of biomembrane and cells under various conditions. There are many interesting shape transitions and dynamic behaviors. We develop membrane models and hydrodynamic simulation methods.

Dynamics of red blood cells and lipid vesicles in flow

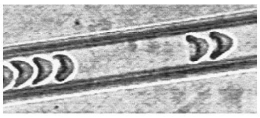
Red blood cell in capillary flow



Slow flow: discocyte



Fast flow: parachute

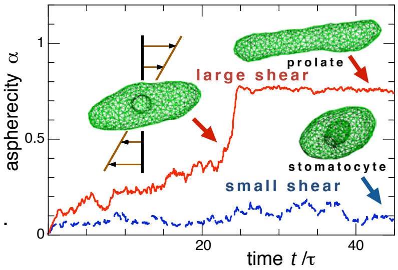


Red blood cells in glass capillary
tsukada et al. Microvasc. Res.61, 231 (2001).

The transition velocity linearly depends on the membrane bending rigidity and shear elasticity.
On the other hand, lipid vesicles elongate to prolate shape.

simulations by MPC-SR with dynamically-triangulated membrane model

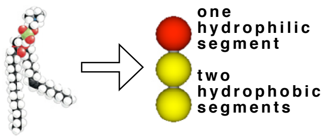
Lipid vesicle in simple shear flow



Stomatocyte to prolate shape.
Shear also induces elongational and shrinking transitions between discocyte and prolate.

Membrane fusion and fission

Solvent-free bilayer membrane model

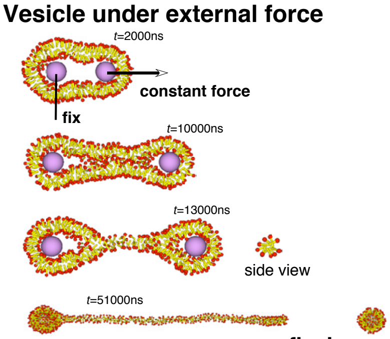


coarse-graining

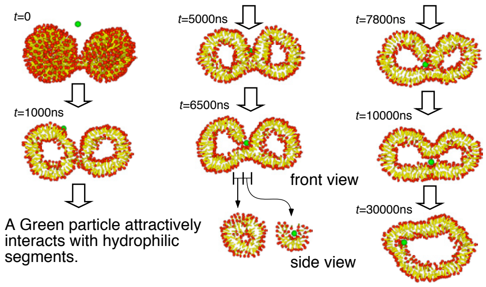
no explicit solvent -> effective attractive potential between hydrophobic segments

We found several pathways of membrane fusion and fission.

Vesicle under external force

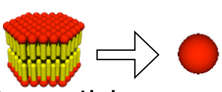


Fusion mediated by particle adhesion



New pathway; Fusion occurs via pore-opening beside stalk intermediate

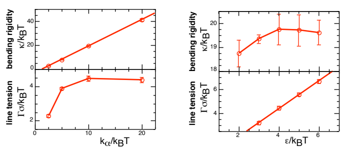
Meshless membrane model



One particle represents a bilayer patch.

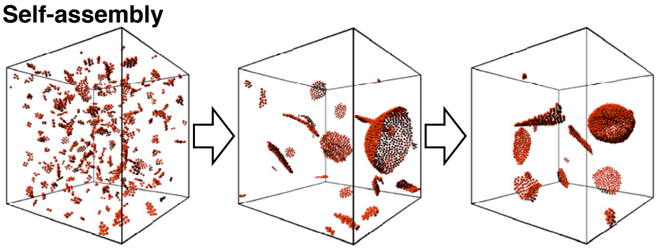
$$U = k_\alpha \sum_i \alpha_{pl}(r_i) + \varepsilon\{\sum_{i<j} U_{rep}(r_{i,j}) + \sum_i U_{att}(\rho_i)\}$$

$\alpha_{pl}(r_i)$: deviation from plane



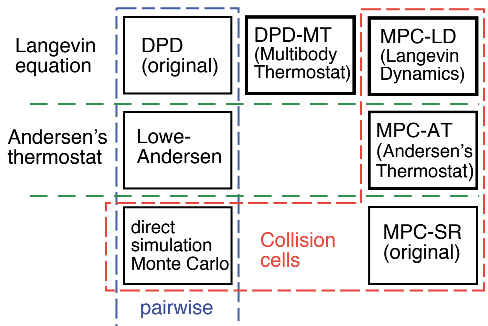
Bending rigidity and line tension can be varied separately.

Self-assembly



Particles aggregate to disks and then forms a vesicle via a bowl-like shape. Hydrodynamic interactions make the aggregation faster.

Hydrodynamic simulation methods



We proposed the intermediate models (DPD-MT and MPC-LD) and clarify the relations between DPD (dissipative particle dynamics) and MPC (multiparticle collision dynamics).
We also clarified artifacts when the angular momentum is not conserved.