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Numerical studies of protein-induced shape changes of liposomes

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Liposomes are closed vesicles formed by lipid bilayer membranes. They have been well studied as simplified models of biological membranes, and are also considered as a possible component for molecular robots. When cytoskeletal proteins, such as actin and tubulin, are polymerized inside liposomes, elongating cytoskeletal filaments push the membrane and deform it. As a result, liposomes change their morphology into a lemon shape, flattened shape, spoon shape, or a shape having long membrane projections. Other proteins, such as talin, induce large holes in the membrane, and liposomes become cup-like shapes. We have analyzed these phenomena using a membrane elasticity model, and showed that the numerical calculations reproduce most of these shape changes. Only a few piconewtons of cytoskeletal forces are needed for large membrane deformations, but actual liposomal morphologies are determined also by the membrane properties, arrangement of cytoskeletal filaments, and pressure difference between inside and outside of the membrane. We expect that the methods used in the calculations may also be useful for designing the molecular robots.