Membrane-mediated cooperativity of proteins and particles

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Indirect interactions mediated by membranes play an important role for the assembly and cooperative function of proteins in membrane shaping and adhesion [1] and for the wrapping of nanoparticles by membranes [2]. The intricate shapes of biological membranes are generated by proteins that locally induce membrane curvature. Indirect curvature-mediated interactions between these proteins arise because the proteins jointly affect the bending energy of the membranes. These curvature-mediated interactions are attractive for arc-shaped proteins and a driving force in the assembly of the proteins during membrane tubulation [3]. Membrane adhesion results from the binding of receptor and ligand proteins that are anchored in the apposing membranes. The binding of these proteins strongly depends on thermal shape fluctuations of the membranes on nanoscales, which leads to a fluctuation-mediated binding cooperativity [4]. Nanoparticles are wrapped spontaneously by membranes if the adhesive interactions between the particles and membranes compensate for the cost of membrane bending. The interplay of adhesion and bending energies during wrapping can lead to attractive curvature-mediated interactions and to the cooperative wrapping of spherical or elongated nanoparticles in membrane tubules [5].

[1] TR Weikl, "Membrane-mediated cooperativity of proteins", Annu. Rev. Phys. Chem. 69, 521 (2018)
[2] AH Bahrami et al., "Wrapping of nanoparticles by membranes", Adv. Colloid Interface Sci. 208, 214 (2014)
[3] F Bonazzi and TR Weikl, "Membrane morphologies induced by arc-shaped scaffolds are determined by arc angle and coverage", submitted
[4] J Hu, R Lipowsky, and TR Weikl, "Binding constants of membrane-anchored receptors and ligands depend strongly on the nanoscale roughness of membranes", PNAS 110, 15283 (2013)
[5] M Raatz and TR Weikl, "Membrane tubulation by elongated and patchy nanoparticles", Adv. Mater. Interfaces 4, 1600325 (2017)