From curvature elasticity to synthetic biology

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The spatial architecture of biological cells is based on fluid membranes that separate space into separate compartments. These membrane compartments, which can be studied in a quantitative manner using model systems such as giant vesicles, are flexible and adjust to their enviroment by changes in their morphology and local composition. Prominent examples for morphological transformations are budding and tubulation of vesicles [1,2], membrane engulfment of nanoparticles [3,4], as well as interfacial phase transitions of droplet-vesicle systems [2]. All of these transformations can by coupled to patterns of intramembrane domains. [5] This multiresponsive behavior arises from the interplay of curvature elasticity, membrane adhesion, lipid demixing, and aqueous phase separation. One intriguing aspect of this interplay is the formation of membrane necks that provide narrow connections between different membrane compartments. The formation of these necks is a crucial step in many biological processes such as cellular uptake and secretion as well as cell division. In all cases, the formation and stability of these necks is governed by local stability conditions that are linear in the membrane curvature. [3,6] Another aspect are curvature-induced forces that push vesicle-bound nanoparticles towards curvature minima or maxima. [4] Recently, a new experimental method has been developed to produce giant vesicles using microfluidic pico-injection. [7] Combining this method with our quantitative understanding of the membrane behavior enables us to construct multiresponsive microcompartments for synthetic biology.

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