Artificial tissue-like systems capable of self-organisation

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During embryo- and morphogenesis biological tissues self-organize in distinct patterns and shapes. These processes are governed by the ability of cells to produce and export molecules in the interstitial space, which then diffuse and inform the behaviour of other cells. The developing embryo is a breath-taking example of such self-regulating material. The lumen in embryos is formed by cells pumping actively ions in the interstitial space, followed by osmotic water flow. The resulting increase in hydraulic pressure in the interstitial space leads to cell-cell fracking and the formation of water filled pockets, which gradually coalesce into one large water filled lumen. Furthermore, the coupling of intra-cellular reactions, transmembrane transport, and diffusion in the interstitial space gives rise to Turing-like patterning instabilities that drive the morphogenesis of the embryo in various types of tissues. Yet, the mechanisms and the biological manifestation of these processes are not at all understood, largely due to the overwhelming complexity of embryos and the lack of appropriate experimental systems.

In this project we will join the expertise of Dr Margarita Staykova in synthetic membrane systems and of Dr Paul McGonigal in synthetic transmembrane ion transporters to construct artificial tissues, made out of lipid vesicles, that can self-organise upon activated ionic transport. The project will progress from fundamental biophysical studies on the mechanisms of embryo development, to the design of artificial materials that can undergo spontaneous morphogenesis and self-differentiation.