Engineering a model cell with DNA nanotechnology

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Abstract

Can we construct a cell from non-living matter? In search for answers, bottom-up synthetic biology has successfully encapsulated functional sets of biomolecules inside lipid vesicles, yet a “living” synthetic cell remains unattained.

Instead of relying exclusively on biological building blocks, the integration of new tools can be a shortcut towards the assembly of a synthetic model cell. This is especially apparent when considering recent advances in 3D laser printing and DNA nanotechnology.

With 2-photon 3D laser printing we were able to print structures on the inside of giant unilamellar lipid vesicles (GUVs) (**Fig. 1**) [1].

DNA nanotechnology allowed us to engineer various functional parts for synthetic cells, which, meanwhile have found early applications as biophysical probes in cell biology [2]. Recently, we engineered functional DNA-based mimics of a cytoskeleton. These cytoskeletons are capable of stimuli-responsive reversible assembly [3], cargo transport (**Fig. 2**) [4], mechanochemical signal transduction [5] and can deform GUVs from within [6].

We further demonstrate the division of DNA-containing GUVs based on phase separation [7] or spontaneous curvature increase [8] and osmosis rather than the biological building blocks of a cell’s division machinery. We derive a parameter-free analytical model which makes quantitative predictions that we verify experimentally. The osmolarity increase can be triggered by enzymatic reactions or by light-triggered release of caged compounds.

Ultimately, by coupling GUV division to their informational content and their function, we aim for a prototype of a synthetic cell capable of evolution.

References

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Figures

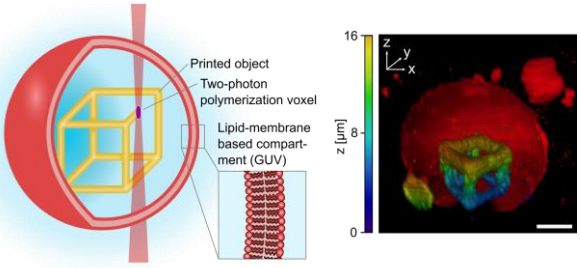

Figure 1. 2-photon 3D laser printing inside of lipid vesicles (GUVs) [1].

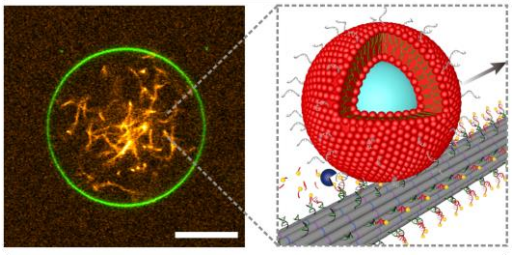

Figure 2. DNA cytoskeletons in GUVs (left) and illustration of transport of vesicular cargo (right) [4]. Scale bar: 10um.

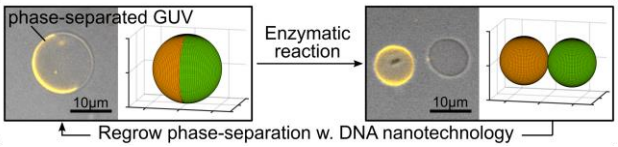

Figure 3. Experimental demonstration and theoretical model of GUV division [6].