Nanotechnology for biophysics, from single molecules towards synthetic cells

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Nanotechnology offers many opportunities to contribute to biophysics and biology. I will present examples where single-molecule tools and nanofabricated structures are used to examine the biophysics from single molecules to cells. I will illustrate the great potential of nanobiology with some recent examples from our lab:

1. Single-molecule tools to probe DNA and DNA-protein [1]
The past two decades have yielded many scanning probe and tweezer technique to probe single biomolecules. I will show some illustrative examples, focusing on the direct visualization of the dynamics of individual supercoils in DNA. Such coiled-up DNA structures are found to move along DNA by diffusion or, unexpectedly, by a fast hopping process.

2. DNA translocation through solid-state nanopores [2]
Solid-state nanopores have proven to be a surprisingly versatile probe for single-molecule analysis of DNA, and much work is carried towards DNA sequencing. I will describe some of our recent findings – specifically DNA knots – as well as our efforts to expand the capabilities of solid-state nanopores even further, in the direction of single-protein detection, graphene nanopores, plasmonic nanopores, and DNA origami nanopores.

3. Exploring biophysics of bacteria with nanofabricated shapes [3]
With nanofabricated structures, we shape bacteria into forms that deviate from their natural phenotype. Specifically, I will show our ability to shape live E. coli bacteria into novel shapes such as rectangles, squares, triangles and circles. We study pattern formation in these geometries. I will show spatiotemporal oscillations of Min proteins – associated with cell division – in such artificial geometries of live E. coli cells.

Finally, I will briefly sketch some of our ideas to explore the building of synthetic cells, specifically our first steps to establish synthetic cell division.

References:

[1] M.T.J. van Loenhout, M.V. de Grunt, C. Dekker, Dynamics of DNA supercoils, Science 338, 94 (2012)

[2] C. Dekker, Solid-state nanopores, Nature Nanotechnology 2, 209 (2007)

[3] F. Wu et al, Nature Nanotechnology 10, 719–726 (2015)