Topic

Bioanalytics, Micro/Nanofabrication, Lab-on-Chip

Content

Overview of analytical techniques that are pivotal in biointerface science & technology, optical single-molecule microscopy, role of advanced micro- and nanofabrication / - advanced surface modification; motivation for and challenges in the downscaling of bio-related experiments with techniques such as micro- and nanofluidic systems.

Abstract

A central challenge of biology is the heterogeneity that prevails at all scales, from entire organisms down to individual cells, organelles, nanoparticles, and molecules. For instance, while sharing the same original genome, each individual cells within a multicellular organism has a unique molecular pool at a given time point, which defines the cell's state, function, and fate. Similarly, biological nanoparticles, including viruses and membrane-enveloped particles participating in inter-cellular communication such as exosomes, exhibit differential properties and molecular contents, which determine their potency and function.

From the awareness of this biological heterogeneity stems a strong appeal for down-scaling bio-related experiments in order to attain the single-cell, -nanoparticle, and -molecule levels, not only to help the understanding of fundamental biological processes, but also to assist the development of effective biomimetic systems for applications in regenerative medicine, tissue engineering and drug delivery.

As an example, the design of next-generation biomimetic nanocarriers for drug delivery, aimed at performing similar tasks to that of exosomes or viruses, requires a precise control of multiple fine-tuned supra-molecular self-assembly processes. This very demanding task obviously relies on analytical approaches allowing for reaching single-cell and single-nanoparticle sensitivity, which would also further the understanding of the interdependent role of the different physicochemical properties of nanoparticles and their influence on the efficiency of cellular uptake and cellular response, which still remain largely unknown despite significant research efforts.

Future progress in this field is thus strongly dependent on developing the ability to characterize the exact physicochemical properties of both natural and artificially-produced nanocarriers, advancing the analytical tools to reach the single nanoparticle level, whereas comprehensive molecular analyses at the single-cell level are of critical importance to evaluate cellular uptake and cellular response.

In this lecture, we will discuss the latest technological developments and current limitations in bioanalytics, and potential use to, for example, devise bioinspired drug-containing nanoparticles and explore the fate of cells treated with them. We will focus on nanotechnology-based approaches enabling to probe and analyze the molecular content of single living cells, and on surface-sensitive microscopy techniques for single-nanoparticle and single-molecule analyses.

Relevant literature

- Rupert, D. *et al.* Methods for the physical characterization and quantification of extracellular vesicles in biological samples. *Biochimica et Biophysica Acta* **1861**, 3164–3179 (2017).
- Higgins, S.G. and Stevens, M.M. Extracting the contents of living cells. *Science* **356** (6336), 379-380 (2017).

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