From single molecules to functional biomaterials

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This modular course will highlight selected aspects of the highly interdisciplinary research field of biomedical engineering. The overall theme ‘From single molecules to functional biomaterials’ emphasizes how basic research in the natural sciences of biology, chemistry, and physics essentially inspire the rational design and development of biomaterials.
The topic will be tackled from three different perspectives:

1. Atomic Force Microscopy (AFM) in Life Sciences

The AFM has become an indispensable toolbox in biomedical engineering. It is routinely used to non-destructively map ultra-structures of all kinds of surfaces including soft biological samples under physiological conditions and with unprecedented lateral resolution. The AFM cantilever can also be used as sensor to quantify interaction forces on the single-molecule level; and simple indentation measurements yield physical properties such as Young’s modulus and stretching modulus of (soft, elastic) biomaterials. The multimodal applications of AFM in life sciences will be presented

2. Carbon nanotubes (CNTs) for biomedical applications

Since 1994 CNTs have been studied extensively for their potential use in biomedical applications. The initial hype has levelled off after 2010 mainly due to growing toxicity concerns in analogy to asbestos, but also owing to an inherent difficulty to define an international CNT standard as prerequisite for clinical approval. Nevertheless, the idea of CNT based pharmaceuticals, biomaterials and sensor platforms are being revisited time and again and is currently experiencing a revival. In this lecture we will discuss and assess the properties of CNTs with respect to possible medical applications as well as their toxic potential.

3. Mimicking the Extracellular Matrix (ECM)

The natural ECM is a three-dimensional structure enriched with biochemical cues and nanoscale features such as interconnected pores, ridges, and fibers that creates a biochemical and mechanical environment for cell growth and proliferation. Re-creating this complex structure to restore damaged tissue and organ functionality is one of the key goals in bioengineering. This lecture will cover the biological requirements and discuss selected materials that are being pursued for tissue engineering applications.

Prerequisites for attending the lecture: All three lectures aim at giving a general overview of fundamental aspects and spotlight a number of examples to convey research directions in this vast field. The level is anticipated to meet the general background of undergrad and graduate students of the natural sciences. The goal of each topic is to convey the importance of acquiring multidisciplinary competences in terms of knowledge base and language in order to successfully collaborate on interdisciplinary projects. Due to the modular separation into three independent topics with only minor overlap students may select only individual contents of this course.