IMPRS on Multiscale Biosystems

Project description

Title: Probing collagen nanomechanics
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Project description: Collagen is the most abundant protein in mammals. Its primary role is to serve as mechanical support in many extracellular matrices such as bones, tendons, skin or blood vessels. Collagen is made of triple helical polypeptide chains that assemble into higher order structures: the collagen fibrils (Fig. 1a). This characteristic hierarchical structure allows for a variety of mechanical functions. Water is an integral part of the collagen structure at the molecular level, and its role is still poorly understood. Recently, it was shown that the conformation of the collagen triple helix changes upon water removal, leading to a contraction of the molecule associated with the generation of considerable tensile stresses (up to 80 MPa).

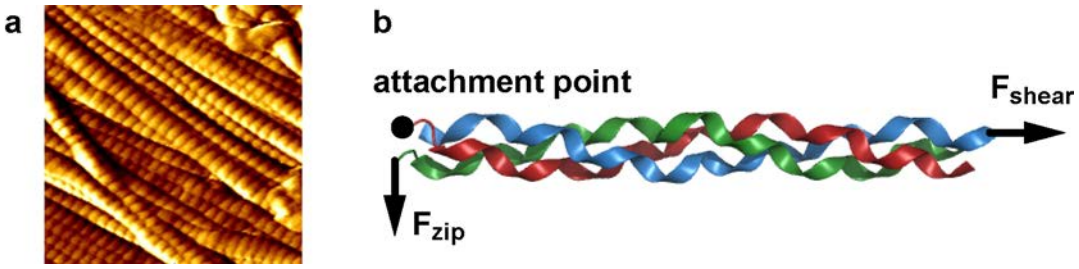

Figure 1. Structure and mechanical properties of collagen. a) Image of collagen fibrils showing the typical band structure. b) Mechanical testing of collagen triple helices. Depending on the geometry, the force can act along the axis of the molecule (shear) or lead to sequential unfolding (zip).

In this project we aim to obtain crucial new information on the structure-function relationship of collagen at the molecular level. Using the atomic force microscope, we will investigate the mechanical properties of individual collagen molecules as well as representative fragments of the collagen triple helix (Fig. 1b). This approach will allow for quantifying the molecular response to perturbations such as fluctuations in hydration, local ionic strength, temperature, etc. The mechanical characteristics of the triple helix will subsequently be compared with the structural properties of higher order assemblies characterized with X-rays and vibrational spectroscopies. This integrative approach will lead to a better understanding of the structural and chemical response of collagen to external stimuli and will open new possibilities for the development of advanced diagnostic tools and the design of specific tissue treatments.

Required background: You should have a background in experimental biophysics or physical chemistry. Experience in basic organic synthesis and peptide chemistry will be an advantage.

Paper to read before the interview: Masic et al. (2014) Osmotic pressure induced tensile forces in tendon collagen. Nature Communications *accepted*

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