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Nanomechanics of individual structures in endothelial cells studied by multiparameter AFM-based experimental methods

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WARNING – IT IS A DRAFT

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1. Preface

Thanks to the rapid development of experimental techniques at the cellular level, over the last century there was a tremendous progress in the fields of human physiology, immunology and therapeutics. The breakthrough discoveries were based mainly on the analysis of biochemistry (either intercellular or intracellular molecular pathways). Mechanical properties of investigated objects were often either completely neglected, or strongly underestimated. However, all living cells are exposed to the action of external forces: fluid-mediated (eg. blood flow) or structure-mediated (eg. body weight strain in bones). The process of converting external mechanical stimuli into biochemical signals (and in turn into physiological responses) is called mechanotransduction.
The most appealing discovery, which evidences for the importance of mechanical properties, refers to the fate of stem cells. In 2006 Engler *et al.* identified a new factor capable to regulate the fate of stem cells: the elasticity of the microenvironment (matrix). Namely, by changing the elastic properties of the substrate, stem cells could be directed towards muscle, bone or even neuronal lineages [1]. On the grounds of the recent discoveries, the new field of science have emerged: *mechanobiology*. It is targeted to study the mechanotransduction processes at the level of tissues and cells, and the way it influences the development, physiology and diseases.
One may wonder what is the range of forces capable to elicit a cellular response. It is reasonable to assume, that the effect of force should exceed the energy of thermal fluctuations. At $37°C$ the thermal energy, kT, is about $4\ pN \cdot nm$. Considering the conformational changes in peptide-based molecular transducers have a characteristic length scale within the range of $1 - 10\ nm$, then it would correspond to the force of $0.4 - 4\ pN$. Interestingly, Finner *et al.* (1994) have estimated, that a single myosin molecule, which drives contractility action and thus can induce cell signaling, is capable to produce a force $3 - 4\ pN$ [2]. Therefore, it turns out that mechanotransduction is induced by forces only slightly higher than thermal fluctuations, *i.e.* within the range of $10^0 - 10^1$ piconewtons.

Physiological relevance of endothelial cells nanomechanics

Techniques to mechanically probing the cell

Cele pracy i struktura pracy

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References

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[2] Silberberg, Y. R., Pelling, A. E., Yakubov, G. E., Crum, W. R., Hawkes, D. J., and Horton, M. a. Mitochondrial displacements in response to nanomechanical forces. *Journal of molecular recognition : JMR 21*, 1 (2008), 30–6.

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