Epithelial Layers Controlling Transitions between Compartments in Organisms.

Modelling and Simulation of Early Stages of Atherosclerosis

Willi Jäger
IWR, BIOMS, University of Heidelberg.
wjaeger@iwr.uni-heidelberg.de

Abstract

Epithelial cells are regulators of barrier function and immune homeostasis. Layers of these cells are controlling the transitions between different compartments of organisms, the exchange of chemical substances, of ions, of fluids, of cells. They are track switches of signalling and regulators coupling processes in different compartments. On cellular level membranes and envelopes are playing a similar role.

In this lecture the endothelial layer, an epithelium that lines the interior surface of blood and lymphatic vessels, will be in the focus of mathematical modelling and simulation. In particular the dynamics of the arterial endothelium separating the lumen and the intima is investigated in the early stage of atherosclerosis or inflammation. Here the evolution of the permeability to substances like LDL, to cytokines, to cells like leukocytes, in particular to monocytes, is modelled and simulated. The blood flow in the vessel is coupled with the filtration flow through the intima, considered as porous elastic medium, with the endothelial layer as separating interface. This investigation is intended as a step to a more comprehensive model for the formation of plagues, a process running on a different time scale.

The research of the last years showed the great importance of the epithelial layers in parts of organisms controlling transitions and the coupling of processes in different compartments. In an outlining overview on different subsystems of the human body, we are demonstrating that similar questions and tasks in mathematical modelling and simulation of model systems are arising and posing challenges for future research. Examples of subsystems, where processes highly important for health are taking place and epithelia play an important role, are the digestive system or the oral system. This lecture is based on joint research with Telma Fortes, Maria Neuss-Radu and Adelia Sequeira and a joint manuscript (in preparation for publication): "Mathematical Modelling of the Early Stage of Atherosclerosis" (2017).