Karlsruher Institut für Technologie

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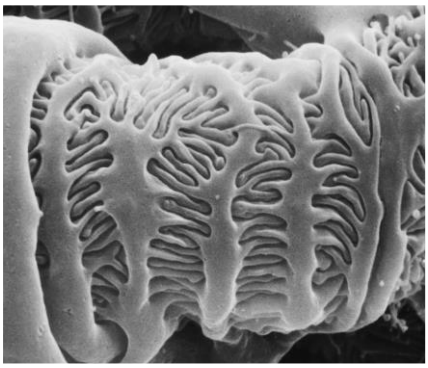
Bachelor-thesis-numerical

Rheological forces during urine formation by plasma filtration in the kidney

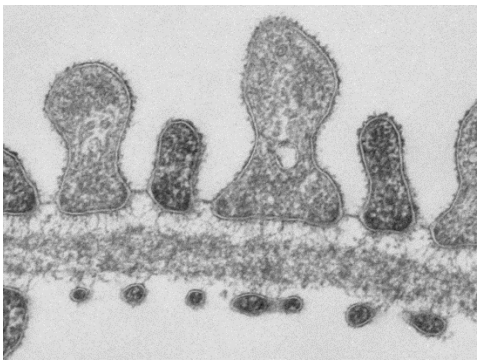
Motivation:
Driven by the blood pressure the kidney permanently filters the blood plasma producing daily 180l filtrate (primary urine). This occurs in the renal glomeruli (renal corpuscles) across a filtration barrier with filtration slits, which are stabilized by a permeable but mechanically resistant slit diaphragm. The filtration slits channel the filtrate flow to the outside. Failure of this function underlies the development of chronic kidney disease that inevitably advances to the loss of any kidney function, currently concerning about 600 million people worldwide.

Content of the thesis:
The present project aims at analysing the rheological forces within the filtration slits. Pressures and flow rates underlying filtration are known. However, the effects of tensile stress and shear stress challenging the stability of the filtration slits are insufficiently understood. A mathematical model has to be developed that allows by variation of the relevant parameters (pressure, flow rate, velocity, dimension of the channel) to define optimal flow dynamic conditions, in order to learn how to minimize the mechanical challenges to the filter.
The specific problem consists that gaps in the filter that may occur during kidney diseases cannot be sealed by adjacent cells approaching each other. It is hypothesized that increasing shear forces prevent the final closure.

Filtration slits as seen by electron microscopy:



En-face view, scanning EM



Cross-sectional view, transmission EM

Requirements:
Computational Fluid Mechanics
Mesh generation
Postprocessing with Tecplot

Supervisors:
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Prof. Dr. Wilhelm Kriz, Institute of Neuroanatomy, Med. Faculty Mannheim

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