

Modelling sodium ion transport in epithelial cells

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Transport of sodium ions (Na^+) plays an important role in human body. Quantitative description of Na^+ fluxes is relevant to the understanding of many physiological processes ranging from renal and gastro-intestinal functions to alveolar gas exchange and embryo implantation in the uterus. Epithelial cells are major players in the sodium transport process. Sodium ions enter the epithelial cell through a highly selective ion channel called the Epithelial Na Channel (ENaC). The majority of these channels are located in microvilli on the apical (lumen facing) surface of the cell (Figure), while Na^+ extrusion from the cytoplasm by Na pump takes place on the opposite side of the cell, on the basolateral membrane, where Na pumps are abundant. This arrangement of Na transporters within the epithelial cell makes trans-epithelial sodium transport possible, i.e. Na^+ transport from the lumen (e.g. from uterine cavity or from the gut) into the interstitial space. This kind of directed transport relies on Na^+ diffusion through the intravilous space into bulk cytoplasm and then toward basal pole of the cell.

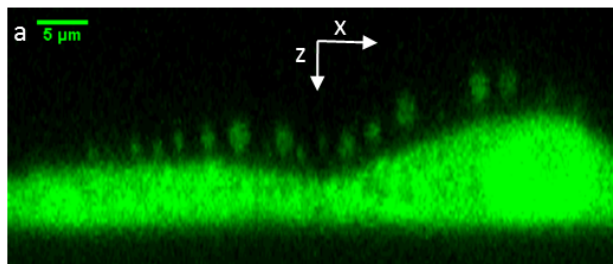


Figure: Confocal cross-section of cultured epithelial cells loaded with Na^+ sensitive fluorescent dye ANG-2. The microvilli are clearly visible on top surface of the cell.

This project will use mathematical modelling to explore the dynamics of intravilous and cytoplasmic concentrations of Na^+ as an emergent phenomenon from the stochastic behaviour of individual ENaC molecules. We will start with the development of a three-dimensional model of an epithelial cell with a microvillus and a number of ENaCs located in it. The number and distribution of ENaCs are not really known from experiments and therefore will be varied in the developed model. Influx of Na^+ ions and the subsequent spread of sodium into the cytoplasm will be investigated under modulations of the dynamics of ENaCs.

This work can be extended to a PhD project which will incorporate more biological aspects in the modelling of intracellular sodium dynamics and include components of computation and data analysis.