Modelling nutrient uptake in the gut using CellML and ApiNATOMY

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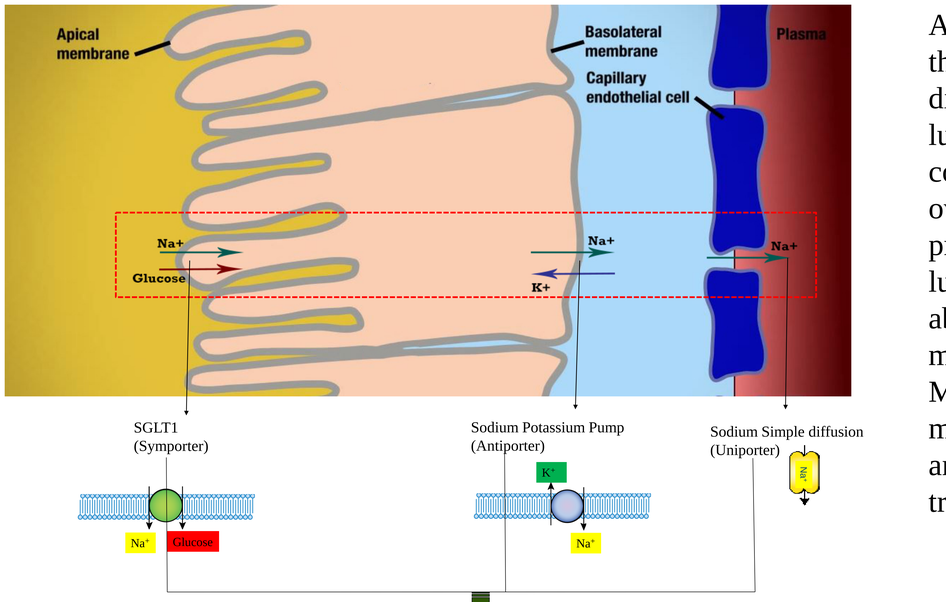
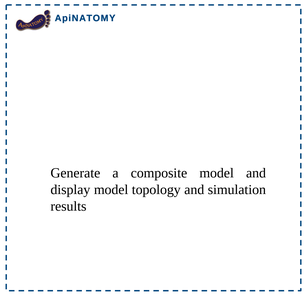
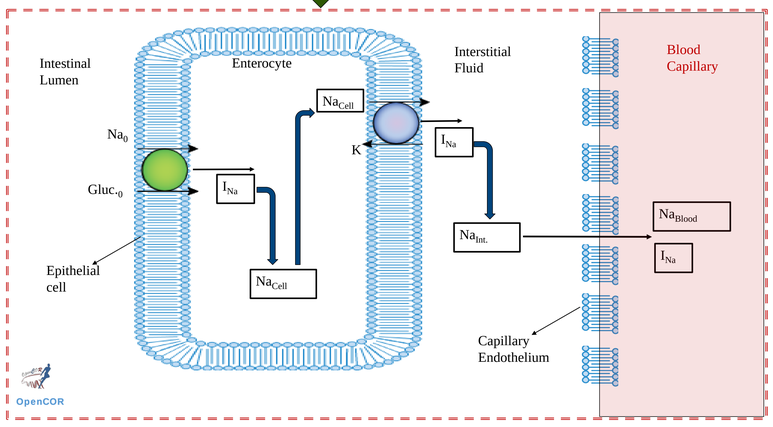
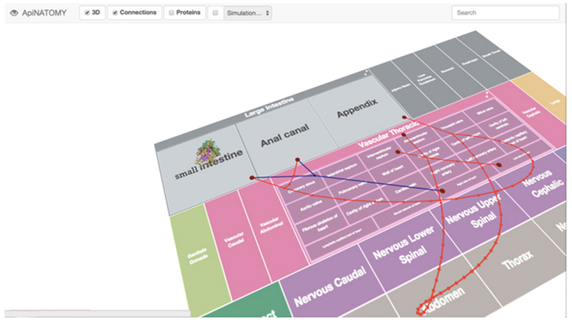
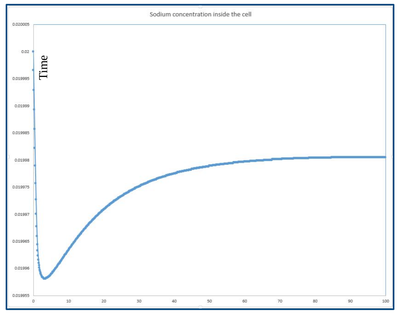
Almost all of the nutrients, electrolytes and water from food are absorbed into blood capillaries through the mucosa of the small intestine. Most absorption processes in the small intestine are driven by an electrochemical gradient of sodium across the apical boundary of epithelial cells (enterocytes) lining the lumen. Transporter proteins embedded in the apical membrane carry sodium and nutrients (e.g. glucose, amino acids) into the enterocytes. Other transporters in the basolateral membane then extrude the molecules into the intersitial space from where they enter capillary blood by diffusion. The graphic on the right shows this process for sodium and glucose. Subsequent transport and metabolism of the absorbed species triggers responses such as hormone release, appetite regulation and growth via complex physiogical feedback pathways.

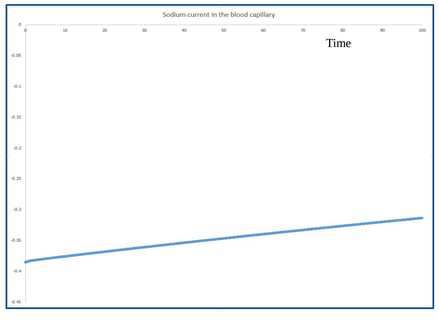












A mechanistic understanding of these pathways and how they are disupted in disease is lacking, partly due to the difficulties of making experimental measurements in the luminal and capillary compartments. A validated computational model of the absorption pathways can overcome these difficulties by providing quantitative predictions of concentrations and transport rates in the lumen, tissue and blood compartments. In this project absorption pathways will be modelled in CellML using models for individual transporters from the Physiome Model Repository and then integrated into a composite model using ApiNATOMY (cite ref) . This poster provides an outline of the process using the pathway for sodium transport as an exemplar.

To Come: K^+, Cl^-, H^+, HCO_3^-, Ca^{2+}, Mg^{2+}, Fe^{2+}, Fe^{3+}, Glucose, Water etc.

Validation by experimental results from colleagues in Liggins institute and UC Davis.

References

[1] Wiseman, G. “Absorption from the intestine” (1964)
[2] Nagpal R; Patel A; Gibson MC” Epithelial topology” (March 2008). BioEssays 30 (3): 260–6.
[3] WARREN J. HEDLEY “Short introduction to CellML” (2004)
[4] Bernard de Bono et al.” ApiNATOMY: A novel toolkit for visualizing multiscale anatomy schematics with phenotype-related information” (2012). Wiley – HGV journal
[5] Bernard de Bono et al.” Functional tissue units and their primary tissue motifs in multi-scale physiology.” (2013) Journal of BIOMEDICAL SEMANTICS
[6] http://co.mbine.org/standards/kisao (Kinetic Simulation Algorithm Ontology)

Acknowledgments

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