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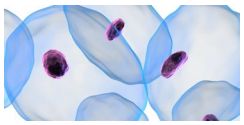

Modeling ferredoxin controlled short-chain fatty acid metabolism of anaerobic microbes in the bovine rumen

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Type of thesis: Computational

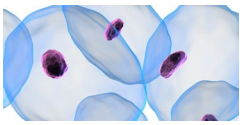
Required competences: ODE modelling, physiology of anaerobic microbes, (genome-scale metabolic modelling)

Acquired competences: Thermodynamics and kinetics of biochemical conversions, Understanding of the ruminal microbial metabolism, Ability to simulate dynamic model systems in Julia, R, Python or MATLAB.

Date: by mutual agreement

Description

Various rumen fermentation models have been developed over the past few decades. These models mathematically represented feed substrate degradation, microbial biomass (representing bacteria and protozoa) and metabolism of short-chain fatty acid production (viz. acetate, propionate and butyrate) through fermentation. A recent model (Van Lingen et al., 2019) also represented methanogenic a cofactor (i.e. NAD+/NADH) controlled framework of the production of short-chain fatty acids. The redox state of the NAD cofactor was, in turn, controlled by the dynamics of hydrogen partial pressure in the rumen environment. The model by Van Lingen et al. (2019) resulted in a fairly accurate dynamics of acetate and propionate in response to intake of feed substrate, whereas the butyrate dynamics may have been simulated more accurately. Apart from the NAD cofactor, ferrodoxin is another cofactor involved in the actual microbial metabolism in the rumen (e.g. Buckel and Thauer, 2013). The latter cofactor is particularly involved in the NADH reduction to NAD+ and the pathway of butyrate production. Incorporating the ferredoxin cofactor in a rumen model as well may improve the prediction of the butyrate dynamics. The student will uniquely incorporate the ferredoxin mechanism in the rumen fermentation modeling framework. Incorporating this mechanism will likely affect the dynamics of butyrate and NADH oxidation and assess if this incorporation improves the



predictive ability of the model. Once a new model has been developed, a model parameter optimization will be performed. Depending on the interest of the student, the development of a genome-scale metabolic model and the application of constraint-based methods such as (dynamic) flux balance analysis could be considered as well.

References

Buckel and Thauer (2013). Energy conservation via electron bifurcating ferredoxin reduction and proton/Na(+) translocating ferredoxin oxidation. Biochim Biophys Acta 1827:94-113. https://doi.org/10.1016/j.bbabio.2012.07.002

Van Lingen, H.J. et al. (2019). Bayesian mechanistic modeling of thermodynamically controlled volatile fatty acid, hydrogen and methane production in the bovine rumen. J Theor Biol 480:150-165. https://doi.org/10.1016/j.jtbi.2019.08.008