Notice of the Final Oral Examination
for the Degree of Master of Science

of

SKYE DORE-HALL

BSc Hons. (Kwantlen Polytechnic University, 2018)

“Ramp Function Approximations of Michaelis-Menten Functions in Biochemical Dynamical Systems”

Department of Mathematics and Statistics

Monday, December 14, 2020
10:00 A.M.
Conducted Remotely

Supervisory Committee:
Dr. Roderick Edwards, Department of Mathematics and Statistics, University of Victoria (Supervisor)
Dr. Pauline van den Driessche, Department of Mathematics and Statistics, UVic (Member)

External Examiner:
Dr. Etienne Farcot, School of Mathematical Sciences, University of Nottingham

Chair of Oral Examination:
Dr. Scott Watson, Department of Political Science, UVic

Dr. Stephen Evans, Acting Dean, Faculty of Graduate Studies
Abstract

In 2019, Adams, Ehlting, and Edwards developed a four-variable system of ordinary differential equations modelling phenylalanine metabolism in plants according to Michaelis-Menten kinetics. Analysis of the model suggested that when a series of reactions known as the Shikimate Ester Loop (SEL) is included, phenylalanine flux into primary metabolic pathways is prioritized over flux into secondary metabolic pathways when the availability of shikimate, a phenylalanine precursor, is low. Adams et al. called this mechanism of metabolic regulation the Precursor Shutoff Valve (PSV). Here, we attempt to simplify Adams and colleagues' model by reducing the system to three variables and replacing the Michaelis-Menten terms with piecewise-defined approximations we call ramp functions. We examine equilibria and stability in this simplified model, and show that PSV-type regulation is still present in the version with the SEL. Then, we define a class of systems structurally similar to the simplified Adams model called biochemical ramp systems. We study the properties of the Jacobian matrices of these systems and then explore equilibria and stability in systems of \( n \geq 2 \) variables. Finally, we make several suggestions regarding future work on biochemical ramp systems.