



University  
of Victoria

Graduate Studies

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

of

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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

## Abstract

In 2019, Adams, Ehling, 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.