School of Mathematical and Statistical Sciences
Arizona State University

M E M O R A N D U M

DATE: February 3, 2022

TO: Faculty and Students

FROM: Professor(s) Erika Camacho Stephen Wirkus
Chair/Co-Chairs of Kathryn Wifvat
Defense for the PhD in Applied Mathematics
Committee Members Erika Camacho
Carl Gardner
John Fricks
Matthias Kawski

DEFENSE ANNOUNCEMENT

Candidate: Kathryn Wifvat

Defense Date: 03/04/2022

Defense Time: 3:00 PM

Virtual Meeting Link: https://asu.zoom.us/j/9861488446

Title: Mathematically Modeling the Impact of RdCVFL in Photoreceptors

Please share this information with colleagues and other students, especially those studying in similar fields. Faculty and students are encouraged to attend. The defending candidate will give a 40 minute talk, after which the committee members will ask questions. There may be time for questions from those in attendance. But, guests are primarily invited to attend as observers and will be excused when the committee begins its deliberations or if the committee wishes to question the candidate privately.

ABSTRACT
-See next page-

PO Box 871804 Tempe, AZ 85287-1804
(480) 965-3951 Fax: (480) 965-8119
http://math.asu.edu

ABSTRACT

Recent experimental and mathematical work has shown the interdependence of the rod and cone photoreceptors with the retinal pigment epithelium in maintaining sight. Accelerated intake of glucose into the cones via the theoredoxin-like rod-derived cone viability factor (RdCVF) is needed as aerobic glycolysis is the primary source of energy production. Reactive oxidative species (ROS) result from the rod and cone metabolism and recent experimental work has shown that the long form of RdCVF (RdCVFL) helps mitigate the negative effects of ROS. In this work we investigate the role of RdCVFL in maintaining the health of the photoreceptors. The results of our mathematical model show the necessity of RdCVFL and also demonstrate additional stable modes that are present in this system. The sensitivity analysis shows the importance of glucose uptake, nutrient levels, and ROS mitigation in maintaining rod and cone health in light-damaged mouse models. Together, these suggest areas on which to focus treatment in order to prolong the photoreceptors, especially in situations where ROS is a contributing factor to their death such as retinitis pigmentosa (RP). A potential treatment with RdCVFL and its effects has never been studied in mathematical models. In this work, we examine an optimal control with the treatment of RdCVFL and mathematically illustrate the potential that this treatment might have for treating degenerative retinal diseases such as RP. Further, we examine optimal controls with the treatment of both RdCVF and RdCVFL in order to mathematically understand the potential that a dual treatment might have for treating degenerative retinal diseases such as RP. Our RdCVFL control terms are nonlinear for biological accuracy but this results in the standard general theorems for existence of optimal controls failing to apply. We then linearize these models to have proof of existence of an optimal control. Both nonlinear and linearized control results are compared and reveal similarly substantial savings rates for rods and cones.