Presentation Titles and Abstracts

Plenary Talks:

Speaker: Mark Lewis, University of Alberta
Title: Spatial dynamics of emerging wildlife diseases
Abstract: In this talk I will present recent research on the spatial dynamics of emerging wildlife diseases. I will analyse models for West Nile virus both in a dynamical context and in a spatial context, using travelling wave theory to describe spread into new environments. I will then describe recent interdisciplinary work on the dynamics of naturally occurring parasites on wild salmon, namely sea lice, and the role played by salmon farms in changing those dynamics for juvenile salmon. In this case, the spatial patterns of infection can be used to deduce the source of disease and, ultimately, to assess the impact of aquaculture on the wild salmon population.

Much of this work is collaborative with IGTC members. The research on salmon parasites is joint with my grad student, Marty Krkosek and others. The work on West Nile virus is joint with Marjorie Wonham, Pauline van den Driessche, Joanna Renclawowicz and Tomas de Camino Beck.

Speaker: Daniel Coombs, UBC
Title: Levels of competition and selection in infectious disease models
Abstract: There are a lot of models for infectious diseases working at various levels (within-cell, within-host, within-population, etc). In understanding the selective pressures acting on infectious agents, it is useful to be able to combine the pressures resulting from these different levels. In this talk, I'll outline some ways of thinking about nested models of infectious disease and present examples to illustrate the processes involved.

Short Talks – Session I:

Chair: Tomas de-Camino-Beck, U. Alberta

Speaker: Omer Dushek, UBC
Title: Analysis of serial engagement and peptide-MHC transport in T cell receptor microclusters
Abstract: During stimulation of a T cell by an antigen-presenting-cell (APC) bearing cognate peptide-major-histocompatibility complexes (pMHC), T cell receptors (TCR) have been shown to form stable micrometer-scale clusters that travel from the periphery to the center of the intercellular contact region. During this journey, pMHC diffusing in the APC membrane may bind and unbind from multiple TCR in the cluster. We present a novel mathematical analysis of this phenomenon to determine the number of clustered TCR bound by a single pMHC, the time spent in the cluster by the pMHC, and the distance that the pMHC might be transported while bound to the microcluster.

Speaker: Jun Allard, UBC
Title: A model of the actin-like MreB helix in prokaryotes

Abstract: MreB is an actin-like protein that forms a helix running the length of cylindrical bacterial cells. I will present a model of the helix. Individual polymers that make up the helical cables are represented by simple force-dependent polymer models bundled into a supramolecular array. Boundary conditions and external forces are provided by a global elasticity model representing the cables as flexible rods buckled into a helix inside the confinement of the cell wall. The model produces a relationship between the pitch of the helix, the thickness of the cables and the total abundance of MreB, and has implications for cell growth, macromolecule trafficking and the polarization of Caulobacter crescentus.

Speaker: Yoichiro Mori, UBC
Title: A three dimensional model of cellular electrophysiology
Abstract: The classical way in which cellular electrophysiology is modeled is with the cable model. Here, we present a generalization of the cable model in which we take into account ionic diffusion and the effect of three dimensional cellular geometry. We apply this modeling methodology to a problem in cardiac physiology.

Speaker: Alexandra Jilkine, UBC
Title: Wave-pinning and cell polarity mechanism from a bistable reaction-diffusion system
Abstract: We report on a phenomenon, termed wave-pinning, that occurs in a simple system of reaction-diffusion (RD) equations with bistable kinetics on a homogeneous finite domain. It is well-known that such equations can produce travelling waves. We study a two-component system with mass conservation where the reaction is merely an interconversion from one form to another. We show that when one of the forms has restricted mobility relative to the other, a wave of concentration that is excited at one end of the domain can move inwards, decelerate, and eventually stop. The resulting stationary profile is stable, as are homogeneous steady states of the system. The phenomenon occurs in a system that does not admit Turing type diffusive instability. We explain the phenomenon and suggest its application to biochemical events in the polarization of motile eukaryotic cells.

Short Talks – Session II:

Chair: Raluca Eftimie, U. Alberta

Speaker: Peter Molnar, U. Alberta
Title: Modelling the impact of sex-selective harvest on the polar bear mating system – a mechanistic approach to the Allee effect
Abstract: Polar bears are susceptible to an Allee effect. Low population densities and an unpredictable sea ice habitat make mate finding an essential component of their reproductive dynamics. Current Canadian harvesting policies encourage hunters to select for males, although intensive sex-selective harvest has already resulted in strongly female-biased sex ratios. If this policy continues, sex-selective harvesting could lead to an Allee effect due to reduced female mating success resulting from a lack of male bears. In order to evaluate current and future harvesting strategies and to predict conditions that would lead to an Allee effect, we developed a two-sex modeling approach that predicts the pairing dynamics of polar bears throughout the mating season, and thus the proportion of successfully mated females, given population size, sex ratio, and mating season duration. The model is parameterized and validated using data from Nunavut, Canada, and describes the observed mating dynamics well. In agreement with observations, the model suggests that there is currently no Allee effect. However, the sex ratio, below which an Allee effect is predicted, is shown to be

strongly dependent on population size and habitat area. Below such a threshold, a decline in fertilization rates will be strongly nonlinear, implying rapid extinction.

Speaker: Jonathan Martin, U. Alberta
Title: A mathematical framework for modeling wildland fire spread
Abstract: We will discuss a mathematical model for fire spread as outlined in a series of papers by G.D. Richards. This model is implemented in Prometheus, the Canadian Forest Services' wildland fire growth prediction software package.

Speaker: Shaun Strohm, UBC Okanagan
Title: The effect of fragmentation on cyclic population dynamics
Abstract: We investigate how fragmentation of habitat affects cyclic population dynamics by constructing a spatially explicit bi-trophic model. Our study is motivated by cyclic mammalian populations such as the Snowshoe Hare, Canada Lynx, several species of Microtus, Lemmings and multiple other species. We investigate whether increasing anthropogenic fragmentation of their habitat could affect the cyclic population dynamics and possibly species persisitence. This fragmentation may be due to temporary disturbances such as forest harvesting, or more permanent disturbances such as roads and agricultural or urban development. We use a Partial Differential Equation (PDE) model to describe the dispersal of predators and prey in a heterogeneous landscape made of high quality and low quality habitat patches. We show that habitat fragmentation significantly affects the amplitude of both predator and prey oscillations in high quality patches. This result may be important to conservation efforts of species in fragmented habitats.

Speaker: Raluca Eftimie, U. Alberta
Title: Modelling complex spatial group patterns: the role of different communication mechanisms
Abstract: Signal reception is essential for the formation and movement of animal groups. I will present a one-dimensional hyperbolic model for group formation that incorporates different mechanisms for the reception of signals emitted by group members. Numerical simulations reveal a wide range of spatial and spatio-temporal patterns. Some of these are classical patterns, such as traveling waves, or stationary pulses. There are also novel patterns, such as breathers and zigzag pulses.

Speaker: Frederic Hamelin, U. Alberta
Title: Uncoupling Isaacs equations in two-player nonzero sum differential games. Parental conflict over care as an example
Abstract: We consider a two-player nonzero-sum differential game with scalar controls, bi-affine in the controls. One typical instance is a game between two players who have, at each instant of time, two pure strategies to mix between. Thus this is also a result about mixed strategy Nash equilibria in differential games. We show that the coupled Isaacs equations lead to a pair of uncoupled first order PDE's in a fashion very much reminiscent of the equalization theorem of static games. In order to provide an example, we address a game arising in Behavioural Ecology. A state-feedback Nash equilibrium is found in closed-form. The solution has a clear interpretation and yields interesting biological implications. This is a joint work with Pierre Bernhard.

Short Talks – Session III:

Chair: Andria Dawson, U. Alberta

Speaker: Geoffrey Hunter, U. Utah
Title: The Big Squeeze: Why strain is so exciting to myocardium
Abstract: A defibrillator generates a large electrical shock that causes the heart to contract in an effort to restore a normal heartbeat. Similarly, contraction and other mechanical stimuli, such as blunt impact to the chest, generate excitable currents in myocardium. These mechanically induced currents can explain normal phenomena such as the Frank-Starling law (increased diastolic volume leads to increased systolic contraction), but are also suspected of having an arrhythmogenic role during regional ischemia. Ischemic myocardium contracts slower and generates less force than normal myocardium. Consequently, strain becomes localized in the region between normal and ischemic myocardium, which then increases the open probability of channels sensitive to or activated by strain. The protein subunits of the human stretch-activated channel have been identified recently and can be activated by strain in the plasma membrane alone. Our proposed Hidden Markov Model of these stretch-activated channels will be explained. Furthermore, the discussion will showcase how the Gillespie Algorithm can produce numerically accurate simulations of single-channel behavior and how the Maximum Likelihood optimization can find “best fit” parameters and Markov Model topology. The talk will conclude by highlighting our future work that will examine stretch-activated channels in 2-D regionally ischemic myocardium and what we hope to explain with our model.

Speaker: Jiafen Gong, U. Alberta
Title: Optimal Cancer radiotherapy treatment schedule for various growth mechanisms under cumulative-radiation effect constraint
Abstract: Usher(1980) derived some optimal fractionated cancer radiotherapy treatment schedules by minimizing the survival fraction of cancerous cells, which is a two-variable function by restricting the cumulative-radiation effect to 1800. But his optimization method is processed as follows: first fixing one variable, finding the minimal survival fraction versus another variable, then minimizing these minimal survival fraction to get the optimal treatment schedule. Obviously, this is not a global optimization. In this talk, we will use both analytic and numerical methods to get a global optimal treatment schedule. We conclude that the solution Usher got almost right for the model itself, but it has no reality usage, for the dose per each treatment is more than three hundred grays, it will kill the patients instantly.

Speaker: Linghong Lu, U. Victoria
Title: Structural principles for dynamics of Glass networks
Abstract: Gene and neural networks can be modeled by piecewise-linear switching systems of differential equations, called Glass networks after their originator. Long before Elowitz and Leibler's 'repressilator' was named, Glass and Pasternack (1978) found a structural principle guaranteeing that such a network must oscillate. While there are many results on determining the dynamics of a given Glass network, there are few other results on structural principles. In this talk, we will describe additional principles allowing certain types of periodic orbit or more complex behaviour, by approaching the problem backwards - i.e. we consider different types of cycles in the state transition diagram (a digraph on an N-cube) and show that there exist Glass networks consistent with this digraph, such that a periodic orbit exists or a complex dynamical behaviour can exist.

Speaker: Liangliang Wang, UBC
Title: Estimating nonlinear mixed-effects models by the generalized profiling method and its application to pharmacokinetics
Abstract: The main objective is to estimate nonlinear mixed-effects models that are expressed as a set of ordinary differential equations (ODE's) using the framework of the generalized profiling method proposed by Ramsay, Hooker, Campbell, and Cao (2007). Four types of parameters are identified and estimated in a cascaded way by a multiple-level nested optimization. The Newton-Raphson algorithm is applied to estimate parameters for each level of optimization with gradients and Hessian matrices worked out analytically with the Implicit Function Theorem. Consequently, some types of parameters are expressed as explicit or implicit functions of other parameters. The dimensionality of the parameter space is reduced, and the optimization surface becomes smoother. This method is applied to several compartment models in pharmacokinetics from both simulated and real data sets.

(Ramsay, J., G. Hooker, D. Campbell, and J. Cao (2007). Parameter estimation for differential equations: A generalized smoothing approach. Journal of the Royal Statistical Society (with discussion).)

Poster Presentations:

Organizer: Omer Dushek, UBC

Title: Understanding cyclical thrombocytopenia: a mathematical modeling approach
Presenter: Raluca Apostu, McGill University

Title: Swimming in slime
Presenter: Sydney Pachmann, UBC

Title: A burst-death model for experimental evolution
Presenter: Jennifer Hubbarde, UBC

Title: A polymer model describes the dynamics of the Min proteins in E.coli
Presenter: Peter Borowski, UBC

Title: Modelling the dynamics of osteoclast cells
Presenter: Erin Prosk, McGill University

Title: The Ortholuge Approach: using the genome-wide distribution of phylogenetic distances to evaluate predicted orthologs. Authors: Matthew D. Whiteside, Fiona, S.L. Brinkman
Presenter: Matthew Whiteside, SFU

Title: Phenomenological modeling of nucleated polymerization of human islet amyloid polypeptide. A combined experimental and theoretical approach.
Presenter: James Bailey, UBC

Title: Modeling the pulsatile and synchronized behaviour of GnRH neurons
Presenter: Anmar Khadra, UBC

Title: First passage time analysis for animal movement
Presenter: Hannah Mckenzie, U. Alberta

Title: Coherence resonance and pattern formation in an eco-epidemiological model with noise
Presenter: Michael Sieber, Universitaet Osnabrueck

Title: Retrospective forest mortality modeling
Presenter: Andria Dawson, U. Alberta

Title: Collective motion in a self-propelled particle model
Presenter: Ryan Lukeman, UBC

Title: A hidden Markov analysis of single particle tracks
Presenter: Raibatak Das, UBC

Title: Modeling body composition with special attention to visceral adiposity
Presenter: Diana White, U. Alberta