Contributed Session 4: Modeling and Math Biology

Spontaneous and evoked glutamate release of NMDA receptors

Justin Blackwell
University of Texas at Arlington, USA
jblackwell@uta.edu
Jianzhong Su and Ege Kavalali

Spontaneous synaptic fusion is a feature in all synapses. These random release events have been extremely instrumental in the analysis of unitary properties of neurotransmission. In this talk we present a mathematical model for the kinetic scheme on NMDA receptors in a synapse. We first consider the diffusion of the neurotransmitter Glutamate within the synaptic cleft and then use this data to differences in the kinetics with respect with the location of the release site. This helps us determine how postsynaptic neurons distinguish evoked and spontaneous neurotransmission and the affect on postsynaptic signaling.

$\longrightarrow \infty \diamond \infty \longleftarrow$

Random Differential Equation Models for Monod Kinetics

Benito Chen-charpentier
University of Wyoming, USA
bchen@uwyo.edu
Dan Stanescu

In modeling of populations and in many other applications parameters are either measured directly or determined by fitting parameters to a mathematical model. These parameters have variability depending on experimental error, the actual population used and many other factors. In this paper we consider that those parameters are random variables with given distributions. We write and solve random differential equations that model Monod growth kinetics. This kinetics is useful, for example, in modeling biofilm growth.

$\longrightarrow \infty \diamond \infty \longleftarrow$

A model of pyoverdine production by P.fluorescens

Hermann Eberl
University Guelph, Canada
heberl@uoguelph.ca
Hedia Fgaier and Robin C McKellar

To overcome iron limitation, many bacteria have developed iron chelating mechanisms, that enable them to bind the metal to organic molecules from which they are later released. We present a mathematical model for the production of the iron chelator pyoverdine by *P. fluorescens*, consisting of five ordinary differential equations. We will give a complete description of the (admittedly simple) dynamical behavior of model solutions and discuss the identification of the 8 reaction parameters from experimental time series for two of the five dependent variables (population count and pyoverdine concentration). This leads to an Edgeworth-Pareto vector optimization problem that we solve numerically.

$\longrightarrow \infty \diamond \infty \longleftarrow$

Positive Periodic Solutions of a Nonautonomous Delay Competitive System

Chikahiro Egami
Numazu National College of Technology, Japan
egami@numazu-ct.ac.jp

In this talk, we discuss a nonautonomous Lotka-Volterra type multispecies competitive system with periodic delays which has the intraspecific competition terms defined by sign changing functions depending on population density monotonically and time periodically.

An existence theorem of positive periodic solutions is established using the coincidence degree theory constructed by Mawhin et.al.. Furthermore, for the cases of constant delays, a sufficient condition for the global attractivity is proved with the Lyapunov method so that the system attains the permanence.

$\longrightarrow \infty \diamond \infty \longleftarrow$

Membrane instabilities driven by the mobility of membrane proteins

Sefi Givli
California Institute of Technology, USA
givli@caltech.edu
Ha Giang and Kaushik Bhattacharya

The interplay between lipids and membrane proteins has an important role in many cell functionalities. It has been experimentally observed that certain types

of functional proteins concentrate in domains of curvature that they prefer, leading to the formation of functionalized domains. In this work, we study the formation of membrane protrusions driven by aggregation of membrane proteins. In particular we focus on protrusions with a lateral size that is small compared to the size of the vesicle. In these cases, the coupling between curvature and lateral protein concentration can lead to instabilities, formation of small clusters of proteins and as a result membrane protrusions. We adopt a continuum approach that generalizes Helfrich energy to include local density and local composition of the membrane. Further, the model accounts for a non-uniform and composition dependent pressure. This feature is important for biological systems that involve actin polymerization. In these systems, the local concentration of certain proteins control the local rate of polymerization, bundling and angle of the actin filaments, which in turn dictate the local pressure that the actin network exert on the membrane. We derive the governing differential equations for the case where both the spontaneous curvature and the mechanical properties depend on composition, and present numerical examples for some specific cases.

$\longrightarrow \infty \diamond \infty \longleftarrow$

Model of viral quasispecies dynamics with nonlinear replication rates and phenotypic mixing

Tanya Kostova
Lawrence Livermore National Laboratory, USA
kostova@llnl.gov

RNA viruses are the fastest mutating living organisms. Due to their high mutation rates they exist in populations consisting of multiple genotypes and phenotypes. The classical quasispecies model assumes constant replication rates. We propose and analyze a model with nonlinear replication rates reflecting the fact that genome replication is a result of transcription and translation processes that depend on the genome concentrations.

$\longrightarrow \infty \diamond \infty \longleftarrow$

Modeling and Simulation of Foreign Body Reactions to Neural Implants

Humberto Perez
University of Texas at Arlington, USA
humbe_pg@uta.edu

Jianzhong Su and Liping Tang

The fibrotic capsulations to neural implant within brains are found to substantially reduce the effectiveness of the devices. While in vitro and in vivo experiments can single out each of the steps in foreign body reaction process leading to the formation of fibrotic tissue surrounding implants, we need the predictive power to analyze the outcome of multiple interactive complex kinetics of various factors and processes and to understand its dynamical behavior during the entire period (up to several months). A mathematical model is constructed to facilitate such a need and to complement experimental work. We report that preliminary simulation results have been consistent with experimental data and the model can provide useful information for future design of implant device.

$\longrightarrow \infty \diamond \infty \longleftarrow$

Mathematical Study of the Impact of Quarantine, Isolation and Vaccination in Curtailing an Epidemic

Chandra nath Podder
University of Manitoba, Canada
umpodder@cc.umanitoba.ca
Abba. B. Gumel, Chris. S. Bowman and Robert. G. McLeod

The quarantine of suspected cases and isolation of individuals with symptoms are two of the primary public health control measures for combatting the spread of a communicable emerging or re-emerging disease. Implementing these measures, however, can inflict significant socio-economic and psychological costs. This paper presents a deterministic compartmental model for assessing the single and combined impact of quarantine and isolation to contain an epidemic. Comparisons are made with a mass vaccination program. The model is simulated using parameters for influenza-type diseases such as SARS. The study shows that even for an epidemic in which asymptomatic transmission does not occur, the quarantine of asymptomatically-infected individuals can be more effective than only isolating individuals with symptoms, if the associated reproductive number is high enough. For the case where asymptomatic transmission occurs, it is shown that isolation is more effective for a disease with a small basic reproduction number and transmission coefficient of asymptomatically-infected individuals. If asymptomatic individuals transmit at a rate that is at least

20% that of symptomatic individuals, quarantine is always more effective. The study further shows that the reduction in disease burden obtained from a combined quarantine and isolation program can be comparable to that obtained by a vaccination program, if the former is implemented quickly enough after the onset of the outbreak. If the implementation of such a quarantine/isolation programme is delayed, however, even for a short while, its effectiveness decreases rapidly.

$\longrightarrow \infty \diamond \infty \longleftarrow$

Asymptotic behavior of solutions to nonlinear differential and functional differential equations

Yuri Rogovchenko
University of Kalmar, Sweden
Yuriy.Rogovchenko@hik.se

We discuss asymptotic behavior of solutions for some classes of higher order nonlinear differential equations and establish conditions for existence of solutions with polynomial-like behavior at infinity.

$\longrightarrow \infty \diamond \infty \longleftarrow$

Role of Finite Recovery in a Mathematical Model of Host-Pathogen

Priti Roy
Barasat Government College, India
pritiwbes@rediffmail.com
Biplab Chattopadhyay.

A mathematical model, similar to that proposed by Anderson and May, is considered. The model represents the interplay of host and pathogen as in biological systems and manifests the time rate of change of these species. A finite recovery rate of the infected population to that of susceptible is incorporated in the model. The model is analysed theoretically and conditions for stable solutions are obtained. Numerical solutions of the model are in conformity with those obtained theoretically. An effort is made to relate the model to specific biological host-pathogen and predator-prey systems.

$\longrightarrow \infty \diamond \infty \longleftarrow$

The model description of neuron and neural system

Liu Shenquan
South China University of Technology, China
mashqliu@scut.edu.cn

In this paper we introduce the model description of neuron (pyramidal cells and purkinje cells) and neural system (hippocampus, visual cortex, thalamocortical and cerebellum). The neuron model contains synapse model, soma and dendrite structure, calcium model and the neural system is depicted by compartment model. The properties of these models are also presentation here. Keywords: passive property, ions channel, synapse,

$\longrightarrow \infty \diamond \infty \longleftarrow$