Complex Adaptive Systems Modeling

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Review of cellular biophysics and modeling: a primer on the computational biology of excitable cells

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Introduction

Mathematics is considered to be a difficult subject, and especially this subject and biology seems immiscible, but this a hard fact that in this era, most of the very important and difficult biological problems are handled with the help of mathematics. This book provides us a sweet mix of biological especially cellular biophysics and mathematical modeling.

A mathematical model is a formalized description or an abstract model of a system using tractable mathematical concepts, formulations and language, the mathematical modeling is a process by which a mathematical model is developed. Several books have been written on mathematical modeling for example few of them are (Riaz et al. 2016; Chaudhry 2016; Dym 2004; Edwards and Edwards 2007; Chaudhry and Al-Mdallal 2019).

Mathematical biology is a science and a specialized discipline by which a biological problem is solved and handled using the concepts and formulation of mathematics. This is one of the most important area of research especially in this era. Many books and research articles have been published where they have solved the complex

biological problems using mathematics, for example (Bellouquid and Delitala 2006; Herzel and Blüthgen 2008; Hiriart-Urruty 2016).

The importance of cell biology cannot be ignored because the origin of life is cell, therefore it is extremely important to study the metabolism, kinetics and other mechanisms of a cell, and this is the reason that many researches have been done in this area. Cellular biophysics can be termed as the physicochemical and quantitative process to study the complex and heterogeneous phenomena and processes of cell biology and in particular the neuroscience, and this book particularly focusses on this topic (Zia and Chaudhry 2016a, b; Gul et al. 2015; Dreij et al. 2011; Chaudhry et al. 2014a, b, c, 2015; Chaudhry and Hanke 2013; Anjum et al. 2020; Abid et al. 2014; Khalid and Chaudhry 2019; Chaudhry et al. 2019; Sohail et al. 2018; Khalid and Chaudrhy 2016).

The first chapter of the book is devoted to describe the definitions and basic concepts of the terms which will be later on used throughout this book. The book consists of five parts where each part contains few chapters to discuss the main theme and the details of that part. This book deals with the temporal phenomenon of the biological problems, which were mathematically dealt using ordinary differential equations. Although, it is not difficult to understand that the inclusion of spatial and temporal together not only adds to the difficulty level but also enhances the size of the book, but even than the author of this review article of the book really feels the deficiency of this part in this book, because in order to understand the true metabolism of the cell keeping in view the in vivo and in vitro aspects, spatial part was also desired to be discussed.

Part I of the book deals with some basis models where their solutions have been discussed using ordinary differential equations. This part consists of five chapters. In the first chapter, compartment modeling approach has been described and some famous compartment models are given. Second chapter discusses the phase diagrams which arise from the solution of differential equations. Third chapter is devoted to discuss about the kinetic rate laws. In fourth chapter, the author discussed some important function families and their characteristic times. In the last chapter of this part, bifurcation (fold, transcritical and pitchfork) diagrams have been discussed in details.

Part II of this book is concerned with the passive membranes. This part consists of three chapters where first chapter deals with the equilibrium potential whereas in particular the Nernst equilibrium potential. The second chapter of this part deals with the current balance equation. The third and last chapter is discussed on the very famous GHK theory of membrane permeation.

Part III of this book is devoted on voltage-gated currents. This part consists of four chapters. The first chapter is written on voltage-gated ionic currents, whereas the second chapters deals with the regenerative ionic currents and bi-stability. In the third chapter, voltage-clamp recording was discussed in detail, where the fourth chapter was focused on Hodgkin-Huxley model of the action potential.

In Part IV of this book, the author discussed the excitability and phase planes. This part contains three chapters where the first chapter talks about the Morris-Lecar model, then its reduced model was also discussed. Second chapter is dealt with phase plane analysis, where 2D autonomous ODEs were handled. The last chapter of this part is concerned with the very important topic of linear stability analysis.

In the last Part V of the book, oscillations and bursting was discussed in detail. The part consists of four chapters. In the first and second chapters of this part, Hopf Bifurcation (Type II excitability and oscillations) and SNIC and SHO Bifurcations (Type I) were discussed respectively. The third chapter deals with the low-threshold calcium spike where the last chapter of this part and book is devoted to describe the synaptic currents.

As the concluding remarks, I found this book really interested and informative. I would like to suggest the author to please add the Matlab programs for the given problems in the next edition. Even then, I would recommend the MS and PhD students of the relevant field, mathematicians and researchers for its reading.

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