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# DIFFERENTIAL EQUATIONS AND MATHEMATICAL BIOLOGY

SECOND EDITION



D. S. JONES, M. J. PLANK,  
AND B. D. SLEEMAN



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# Differential Equations And Mathematical Biology

**Stavros Busenberg**



## **Differential Equations And Mathematical Biology:**

**Differential Equations and Mathematical Biology** D.S. Jones, Michael Plank, B.D. Sleeman, 2009-11-09 Deepen students understanding of biological phenomena Suitable for courses on differential equations with applications to mathematical biology or as an introduction to mathematical biology Differential Equations and Mathematical Biology Second Edition introduces students in the physical mathematical and biological sciences to fundamental models **Differential Equations and Mathematical Biology** D.S. Jones, B.D. Sleeman, 2003-02-26 The conjoining of mathematics and biology has brought about significant advances in both areas with mathematics providing a tool for modelling and understanding biological phenomena and biology stimulating developments in the theory of nonlinear differential equations The continued application of mathematics to biology holds great promise and in fact may be the applied mathematics of the 21st century Differential Equations and Mathematical Biology provides a detailed treatment of both ordinary and partial differential equations techniques for their solution and their use in a variety of biological applications The presentation includes the fundamental techniques of nonlinear differential equations bifurcation theory and the impact of chaos on discrete time biological modelling The authors provide generous coverage of numerical techniques and address a range of important applications including heart physiology nerve pulse transmission chemical reactions tumour growth and epidemics This book is the ideal vehicle for introducing the challenges of biology to mathematicians and likewise delivering key mathematical tools to biologists Carefully designed for such multiple purposes it serves equally well as a professional reference and as a text for coursework *Differential Equations and Mathematical Biology* D. S. Jones, 2012-01-24 Over the past decade mathematics has made a considerable impact as a tool with which to model and understand biological phenomena In return biology has confronted the mathematician with a variety of challenging problems which have stimulated developments in the theory of nonlinear differential equations This book is the outcome of the need to introduce undergraduates of mathematics the physical and biological sciences to some of those developments It is primarily directed towards students with a mathematical background up to and including that normally taught in a first year physical science degree of a British university sophomore year in a North American university who are interested in the application of mathematics to biological and physical situations Chapter 1 is introductory showing how the study of first order ordinary differential equations may be used to model the growth of a population monitoring the administration of drugs and the mechanism by which living cells divide In Chapter 2 a fairly comprehensive account of linear ordinary differential equations with constant coefficients is given Such equations arise frequently in the discussion of the biological models encountered throughout the text Chapter 3 is devoted to modelling biological phenomena and in particular includes i physiology of the heart beat cycle ii blood flow iii the transmission of electrochemical pulses in the nerve iv the Belousov Zhabotinskii chemical reaction and v predator prey

models      **Mathematical Biology** Christina Alvey, Daniel Alvey, 2024-08-09 This text serves as an exploration of the beautiful topic of mathematical biology through the lens of discrete and differential equations. Intended for students who have completed differential and integral calculus, *Mathematical Biology: Discrete and Differential Equations* allows students to explore topics such as bifurcation diagrams, nullclines, discrete dynamics, and SIR models for disease spread, which are often reserved for more advanced undergraduate or graduate courses. These exciting topics are sprinkled throughout the book alongside the more typical first and second order linear differential equations and systems of linear differential equations. This class-tested text is written in a conversational, welcoming voice which should help invite students along as they discover the magic of mathematical biology and both discrete and differential equations. A focus is placed on examples with solutions written out step by step, including computational steps, with the goal of being as easy as possible for students to independently follow along. Rich in applications, this book can be used for a semester-long course in either differential equations or mathematical biology. Alternatively, it can serve as a companion text for a two-semester sequence beginning with discrete time systems, extending through a wide array of topics in differential equations and culminating in systems, SIR models, and other applications.

**Differential Equations and Mathematical Biology** D. S. Jones, 2014-01-14 Over the past decade, mathematics has made a considerable impact as a tool with which to model and understand biological phenomena. In return, biology has confronted the mathematician with a variety of challenging problems which have stimulated developments in the theory of nonlinear differential equations. This book is the outcome of the need to introduce undergraduates of mathematics, the physical and biological sciences to some of those developments. It is primarily directed towards students with a mathematical background up to and including that normally taught in a first year physical science degree of a British university, a sophomore year in a North American university, who are interested in the application of mathematics to biological and physical situations. Chapter 1 is introductory, showing how the study of first order ordinary differential equations may be used to model the growth of a population, monitoring the administration of drugs, and the mechanism by which living cells divide. In Chapter 2, a fairly comprehensive account of linear ordinary differential equations with constant coefficients is given. Such equations arise frequently in the discussion of the biological models encountered throughout the text. Chapter 3 is devoted to modelling biological phenomena and in particular includes: i) physiology of the heart beat cycle, ii) blood flow, iii) the transmission of electrochemical pulses in the nerve, iv) the Belousov-Zhabotinskii chemical reaction, and v) predator-prey models.

**Differential Equations with Applications to Biology** Shigui Ruan, Gail Susan Kohl, Wolkowicz, Jianhong Wu, 1999 This book presents the proceedings from the International Conference held in Halifax, NS in July 1997. Funded by The Fields Institute and Le Centre de Recherches Mathématiques, the conference was held in honor of the retirement of Professors Lynn Erbe and Herb I. Freedman, University of Alberta. Featured topics include ordinary, partial, functional, and stochastic differential equations and their applications to biology, epidemiology, neurobiology, physiology, and

other related areas The 41 papers included in this volume represent the recent work of leading researchers over a wide range of subjects including bifurcation theory chaos stability theory boundary value problems persistence theory neural networks disease transmission population dynamics pattern formation and more The text would be suitable for a graduate or advanced undergraduate course study in mathematical biology Features An overview of current developments in differential equations and mathematical biology Authoritative contributions from over 60 leading worldwide researchers Original refereed contributions

*Differential Equations and Mathematical Biology, Second Edition* D.S. Jones, Michael Plank, B.D. Sleeman, 2009-11-09 Deepen students understanding of biological phenomena Suitable for courses on differential equations with applications to mathematical biology or as an introduction to mathematical biology Differential Equations and Mathematical Biology Second Edition introduces students in the physical mathematical and biological sciences to fundamental modeling and analytical techniques used to understand biological phenomena In this edition many of the chapters have been expanded to include new and topical material New to the Second Edition A section on spiral waves Recent developments in tumor biology More on the numerical solution of differential equations and numerical bifurcation analysis MATLAB files available for download online Many additional examples and exercises This textbook shows how first order ordinary differential equations ODEs are used to model the growth of a population the administration of drugs and the mechanism by which living cells divide The authors present linear ODEs with constant coefficients extend the theory to systems of equations model biological phenomena and offer solutions to first order autonomous systems of nonlinear differential equations using the Poincaré phase plane They also analyze the heartbeat nerve impulse transmission chemical reactions and predator prey problems After covering partial differential equations and evolutionary equations the book discusses diffusion processes the theory of bifurcation and chaotic behavior It concludes with problems of tumor growth and the spread of infectious diseases

**Modeling Differential Equations in Biology** Clifford Henry Taubes, 2008-01-17 Based on a very successful one semester course taught at Harvard this text teaches students in the life sciences how to use differential equations to help their research It needs only a semester's background in calculus Ideas from linear algebra and partial differential equations that are most useful to the life sciences are introduced as needed and in the context of life science applications are drawn from real published papers It also teaches students how to recognize when differential equations can help focus research A course taught with this book can replace the standard course in multivariable calculus that is more usually suited to engineers and physicists

**Modeling and Differential Equations in Biology** T. A. Burton, 2017-10-05 First published in 1980 CRC Press is an imprint of Taylor Francis

*Methods of Small Parameter in Mathematical Biology* Jacek Banasiak, Mirosław Lachowicz, 2014-04-19 This monograph presents new tools for modeling multiscale biological processes Natural processes are usually driven by mechanisms widely differing from each other in the time or space scale at which they operate and thus should be described by appropriate multiscale models However looking at

all such scales simultaneously is often infeasible costly and provides information that is redundant for a particular application Hence there has been a growing interest in providing a more focused description of multiscale processes by aggregating variables in a way that is relevant to the purpose at hand and preserves the salient features of the dynamics Many ad hoc methods have been devised and the aim of this book is to present a systematic way of deriving the so called limit equations for such aggregated variables and ensuring that the coefficients of these equations encapsulate the relevant information from the discarded levels of description Since any approximation is only valid if an estimate of the incurred error is available the tools the authors describe allow for proving that the solutions to the original multiscale family of equations converge to the solution of the limit equation if the relevant parameter converges to its critical value The chapters are arranged according to the mathematical complexity of the analysis from systems of ordinary linear differential equations through nonlinear ordinary differential equations to linear and nonlinear partial differential equations Many chapters begin with a survey of mathematical techniques needed for the analysis All problems discussed in this book belong to the class of singularly perturbed problems that is problems in which the structure of the limit equation is significantly different from that of the multiscale model Such problems appear in all areas of science and can be attacked using many techniques Methods of Small Parameter in Mathematical Biology will appeal to senior undergraduate and graduate students in applied and

biomathematics as well as researchers specializing in differential equations and asymptotic analysis **Modeling and Differential Equations in Biology** T. A. Burton, 1980-09-01 Persistence in lotka volterra models of food chains and competition Mathematical models of humoral immune response Mathematical models of dose and cell cycle effects in multifraction radiotherapy Theoretical and experimental investigations of microbial competition in continuous culture A liapunov functional for a class of reaction diffusion systems Stochastic prey predator relationships Coexistence in predator prey systems Stability of some multispecies population models Population dynamics in patchy environments Limit cycles in a model of b cell simulation Optimal age specific harvesting policy for a continuous time population model Models involving differential and integral equations appropriate for describing a temperature dependent predator prey mite ecosystem on apples **Delay Differential Equations and Applications to Biology** Fathalla A. Rihan, 2021-08-19 This book discusses the numerical treatment of delay differential equations and their applications in bioscience A wide range of delay differential equations are discussed with integer and fractional order derivatives to demonstrate their richer mathematical framework compared to differential equations without memory for the analysis of dynamical systems The book also provides interesting applications of delay differential equations in infectious diseases including COVID 19 It will be valuable to mathematicians and specialists associated with mathematical biology mathematical modelling life sciences immunology and infectious diseases **Delay Differential Equation Models in Mathematical Biology** Jonathan Erwin Forde, 2005 Differential

Equations and Applications in Ecology, Epidemics, and Population Problems Stavros Busenberg, 2012-12-02 Differential

Equations and Applications in Ecology Epidemics and Population Problems is composed of papers and abstracts presented at the 1981 research conference on Differential Equations and Applications to Ecology Epidemics and Population Problems held at Harvey Mudd College The reported researches consist of mathematics that is either a direct outgrowth from questions in population biology and biomathematics or applicable to such questions The content of this volume are collected in four groups The first group addresses aspects of population dynamics that involve the interaction between spatial and temporal effects The second group covers other questions in population dynamics and some other areas of biomathematics The third group deals with topics in differential and functional differential equations that are continuing to find important applications in mathematical biology The last group comprises of work on various aspects of differential equations and dynamical systems not essentially motivated by biological applications This book is valuable to students and researchers in theoretical biology and biomathematics as well as to those interested in modern applications of differential equations **Frontiers in**

**Mathematical Biology** Simon A. Levin, 2013-03-13 From a mathematical point of view physiologically structured population models are an underdeveloped branch of the theory of infinite dimensional dynamical systems We have called attention to four aspects i A choice has to be made about the kind of equations one extracts from the predominantly verbal arguments about the basic assumptions and subsequently uses as a starting point for a rigorous mathematical analysis Though differential equations are easy to formulate different mechanisms don't interact in infinitesimal time intervals and so end up as separate terms in the equations they may be hard to interpret rigorously as infinitesimal generators Integral equations constitute an attractive alternative ii The ability of physiologically structured population models to increase our understanding of the relation between mechanisms at the  $i$  level and phenomena at the  $p$  level will depend strongly on the development of dynamical systems lab facilities which are applicable to this class of models iii Physiologically structured population models are ideally suited for the formulation of evolutionary questions Apart from the special case of age see Charlesworth 1980 Yodzis 1989 Caswell 1989 and the references given there hardly any theory exists at the moment This will hopefully change rapidly in the coming years Again the development of appropriate software may turn out to be crucial

**Differential Equations Models in Biology, Epidemiology and Ecology** Stavros Busenberg, Mario Martelli, 2013-03-08 The past forty years have been the stage for the maturation of mathematical biology as a scientific field The foundations laid by the pioneers of the field during the first half of this century have been combined with advances in applied mathematics and the computational sciences to create a vibrant area of scientific research with established research journals professional societies deep subspecialty areas and graduate education programs Mathematical biology is by its very nature cross disciplinary and research papers appear in mathematics biology and other scientific journals as well as in the specialty journals devoted to mathematical and theoretical biology Multiple author papers are common and so are collaborations between individuals who have academic bases in different traditional departments Those who seek to keep abreast of current

trends and problems need to interact with research workers from a much broader spectrum of fields than is common in the traditional mono culture disciplines Consequently it is beneficial to have occasions which bring together significant numbers of workers in this field in a forum that encourages the exchange of ideas and which leads to a timely publication of the work that is presented Such an occasion occurred during January 13 to 16 1990 when almost two hundred research workers participated in an international conference on Differential Equations and Applications to Biology and Population Dynamics which was held in Claremont

Introduction to Mathematical Biology Ching Shan Chou, Avner Friedman, 2016-04-27 This book is based on a one semester course that the authors have been teaching for several years and includes two sets of case studies The first includes chemostat models predator prey interaction competition among species the spread of infectious diseases and oscillations arising from bifurcations In developing these topics readers will also be introduced to the basic theory of ordinary differential equations and how to work with MATLAB without having any prior programming experience The second set of case studies were adapted from recent and current research papers to the level of the students Topics have been selected based on public health interest This includes the risk of atherosclerosis associated with high cholesterol levels cancer and immune interactions cancer therapy and tuberculosis Readers will experience how mathematical models and their numerical simulations can provide explanations that guide biological and biomedical research Considered to be the undergraduate companion to the more advanced book Mathematical Modeling of Biological Processes A Friedman C Y Kao Springer 2014 this book is geared towards undergraduate students with little background in mathematics and no biological background

Essential Mathematical Biology Nicholas Britton, 2005-12-16 This self contained introduction to the fast growing field of Mathematical Biology is written for students with a mathematical background It sets the subject in a historical context and guides the reader towards questions of current research interest A broad range of topics is covered including Population dynamics Infectious diseases Population genetics and evolution Dispersal Molecular and cellular biology Pattern formation and Cancer modelling Particular attention is paid to situations where the simple assumptions of homogeneity made in early models break down and the process of mathematical modelling is seen in action

**Biology in Time and Space** James P. Keener, 2021

**Mathematical Biology** Avner Friedman, 2018-06-14 The fast growing field of mathematical biology addresses biological questions using mathematical models from areas such as dynamical systems probability statistics and discrete mathematics This book considers models that are described by systems of partial differential equations and it focuses on modeling rather than on numerical methods and simulations The models studied are concerned with population dynamics cancer risk of plaque growth associated with high cholesterol and wound healing A rich variety of open problems demonstrates the exciting challenges and opportunities for research at the interface of mathematics and biology This book primarily addresses students and researchers in mathematics who do not necessarily have any background in biology and who may have had little exposure to PDEs



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