

DYNAMIC MODELS IN BIOLOGY



STEPHEN P. ELLNER AND
JOHN GUCKENHEIMER



Dynamic Models In Biology

Franco Bagnoli, Stefano Ruffo



Dynamic Models In Biology:

Dynamic Models in Biology Stephen P. Ellner, John Guckenheimer, 2011-09-19 From controlling disease outbreaks to predicting heart attacks dynamic models are increasingly crucial for understanding biological processes Many universities are starting undergraduate programs in computational biology to introduce students to this rapidly growing field In *Dynamic Models in Biology* the first text on dynamic models specifically written for undergraduate students in the biological sciences ecologist Stephen Ellner and mathematician John Guckenheimer teach students how to understand build and use dynamic models in biology Developed from a course taught by Ellner and Guckenheimer at Cornell University the book is organized around biological applications with mathematics and computing developed through case studies at the molecular cellular and population levels The authors cover both simple analytic models the sort usually found in mathematical biology texts and the complex computational models now used by both biologists and mathematicians Linked to a Web site with computer lab materials and exercises *Dynamic Models in Biology* is a major new introduction to dynamic models for students in the biological sciences mathematics and engineering

Dynamical Models in Biology Miklós Farkas, 2001-06-15 *Dynamic Models in Biology* offers an introduction to modern mathematical biology This book provides a short introduction to modern mathematical methods in modeling dynamical phenomena and treats the broad topics of population dynamics epidemiology evolution immunology morphogenesis and pattern formation Primarily employing differential equations the author presents accessible descriptions of difficult mathematical models Recent mathematical results are included but the author's presentation gives intuitive meaning to all the main formulae Besides mathematicians who want to get acquainted with this relatively new field of applications this book is useful for physicians biologists agricultural engineers and environmentalists Key Topics Include Chaotic dynamics of populations The spread of sexually transmitted diseases Problems of the origin of life Models of immunology Formation of animal hide patterns The intuitive meaning of mathematical formulae explained with many figures Applying new mathematical results in modeling biological phenomena Miklos Farkas is a professor at Budapest University of Technology where he has researched and instructed mathematics for over thirty years He has taught at universities in the former Soviet Union Canada Australia Venezuela Nigeria India and Columbia Prof Farkas received the 1999 Bolyai Award of the Hungarian Academy of Science and the 2001 Albert Szentgyorgyi Award of the Hungarian Ministry of Education A down to earth introduction to the growing field of modern mathematical biology Also includes appendices which provide background material that goes beyond advanced calculus and linear algebra

Dynamical Models of Biology and Medicine Yang Kuang, Meng Fan, Shengqiang Liu, Wanbiao Ma, 2019-10-04 Mathematical and computational modeling approaches in biological and medical research are experiencing rapid growth globally This Special Issue Book intends to scratch the surface of this exciting phenomenon The subject areas covered involve general mathematical methods and their applications in biology and medicine with an emphasis on work related to mathematical and computational modeling of the

complex dynamics observed in biological and medical research Fourteen rigorously reviewed papers were included in this Special Issue These papers cover several timely topics relating to classical population biology fundamental biology and modern medicine While the authors of these papers dealt with very different modeling questions they were all motivated by specific applications in biology and medicine and employed innovative mathematical and computational methods to study the complex dynamics of their models We hope that these papers detail case studies that will inspire many additional mathematical modeling efforts in biology and medicine

Dynamical Models in Biology Miklós Farkas, 2001-06-06

Dynamic Models in Biology offers an introduction to modern mathematical biology This book provides a short introduction to modern mathematical methods in modeling dynamical phenomena and treats the broad topics of population dynamics epidemiology evolution immunology morphogenesis and pattern formation Primarily employing differential equations the author presents accessible descriptions of difficult mathematical models Recent mathematical results are included but the author's presentation gives intuitive meaning to all the main formulae Besides mathematicians who want to get acquainted with this relatively new field of applications this book is useful for physicians biologists agricultural engineers and environmentalists Key Topics Include Chaotic dynamics of populations The spread of sexually transmitted diseases Problems of the origin of life Models of immunology Formation of animal hide patterns The intuitive meaning of mathematical formulae explained with many figures Applying new mathematical results in modeling biological phenomena Miklos Farkas is a professor at Budapest University of Technology where he has researched and instructed mathematics for over thirty years He has taught at universities in the former Soviet Union Canada Australia Venezuela Nigeria India and Columbia Prof Farkas received the 1999 Bolyai Award of the Hungarian Academy of Science and the 2001 Albert Szentgyorgyi Award of the Hungarian Ministry of Education A down to earth introduction to the growing field of modern mathematical biology Also includes appendices which provide background material that goes beyond advanced calculus and linear algebra

Dynamical Modeling of Biological Systems Stilianos Louca, 2023-06-07 This book introduces concepts and practical tools for dynamical mathematical modeling of biological systems Dynamical models describe the behavior of a system over time as a result of internal feedback loops and external forcing based on mathematically formulated dynamical laws similarly to how Newton's laws describe the movement of celestial bodies Dynamical models are increasingly popular in biology as they tend to be more powerful than static regression models This book is meant for undergraduate and graduate students in physics applied mathematics and data science with an interest in biology as well as students in biology with a strong interest in mathematical methods The book covers deterministic models for example differential equations stochastic models for example Markov chains and autoregressive models and model independent aspects of time series analysis Plenty of examples and exercises are included often taken or inspired from the scientific literature and covering a broad range of topics such as neuroscience cell biology genetics evolution ecology microbiology physiology epidemiology and conservation The book

delivers generic modeling techniques used across a wide range of situations in biology and hence readers from other scientific disciplines will find that much of the material is also applicable in their own field Proofs of most mathematical statements are included for the interested reader but are not essential for a practical understanding of the material The book introduces the popular scientific programming language MATLAB as a tool for simulating models fitting models to data and visualizing data and model predictions The material taught is current as of MATLAB version 2022b The material is taught in a sufficiently general way that also permits the use of alternative programming languages

Dynamic Models and Control of Biological Systems Vadrevu Sree Hari Rao,Ponnada Raja Sekhara Rao,2009-07-30 Mathematical Biology has grown at an astonishing rate and has established itself as a distinct discipline Mathematical modeling is now being applied in every major discipline in the biological sciences Though the field has become increasingly large and specialized this book remains important as a text that introduces some of the exciting problems which arise in the biological sciences and gives some indication of the wide spectrum of questions that modeling can address Mathematical Models in Biology Leah Edelstein-Keshet,1988-01-01 Mathematical Models in Biology is an introductory book for readers interested in biological applications of mathematics and modeling in biology A favorite in the mathematical biology community it shows how relatively simple mathematics can be applied to a variety of models to draw interesting conclusions Connections are made between diverse biological examples linked by common mathematical themes A variety of discrete and continuous ordinary and partial differential equation models are explored Although great advances have taken place in many of the topics covered the simple lessons contained in this book are still important and informative Audience the book does not assume too much background knowledge essentially some calculus and high school algebra It was originally written with third and fourth year undergraduate mathematical biology majors in mind however it was picked up by beginning graduate students as well as researchers in math and some in biology who wanted to learn about this field

Dynamical Models of Biology and Medicine Meng Fan,Yang Kuang,Shengqiang Liu,Wanbiao Ma,2019 Mathematical and computational modeling approaches in biological and medical research are experiencing rapid growth globally This Special Issue Book intends to scratch the surface of this exciting phenomenon The subject areas covered involve general mathematical methods and their applications in biology and medicine with an emphasis on work related to mathematical and computational modeling of the complex dynamics observed in biological and medical research Fourteen rigorously reviewed papers were included in this Special Issue These papers cover several timely topics relating to classical population biology fundamental biology and modern medicine While the authors of these papers dealt with very different modeling questions they were all motivated by specific applications in biology and medicine and employed innovative mathematical and computational methods to study the complex dynamics of their models We hope that these papers detail case studies that will inspire many additional mathematical modeling efforts in biology and medicine

A Mathematical Treatment of Dynamical Models in Biological Science

Kristína Smítalová, Štefan Šujan, 1991 Providing a comprehensive introduction to mathematical modelling in biology and ecology this book presents numerous results and developments The basic mathematical facts on the theory of the dynamics of biological communities are presented with emphasis placed on the quantitative aspects *Modeling Dynamic Biological Systems* Bruce Hannon, Matthias Ruth, 2014-07-05 Many biologists and ecologists have developed models that find widespread use in theoretical investigations and in applications to organism behavior disease control population and metapopulation theory ecosystem dynamics and environmental management This book captures and extends the process of model development by concentrating on the dynamic aspects of these processes and by providing the tools such that virtually anyone with basic knowledge in the Life Sciences can develop meaningful dynamic models Examples of the systems modeled in the book range from models of cell development the beating heart the growth and spread of insects spatial competition and extinction to the spread and control of epidemics including the conditions for the development of chaos Key features easy to learn and easy to use software examples from many subdisciplines of biology covering models of cells organisms populations and metapopulations no prior computer or programming experience required Key benefits learn how to develop modeling skills and system thinking on your own rather than use models developed by others be able to easily run models under alternative assumptions and investigate the implications of these assumptions for the dynamics of the biological system being modeled develop skills to assess the dynamics of biological systems Biological Fluid Dynamics: Modeling, Computations, and Applications Anita T. Layton, Sarah D. Olson, 2014-10-14 This volume contains the Proceedings of the AMS Special Session on Biological Fluid Dynamics Modeling Computation and Applications held on October 13 2012 at Tulane University New Orleans Louisiana In recent years there has been increasing interest in the development and application of advanced computational techniques for simulating fluid motion driven by immersed flexible structures That interest is motivated in large part by the multitude of applications in physiology and biology In some biological systems fluid motion is driven by active biological tissues which are typically constructed of fibers that are surrounded by fluid Not only do the fibers hold the tissues together they also transmit forces that ultimately result in fluid motion In other examples the fluid may flow through conduits such as blood vessels or airways that are flexible or active That is those conduits may react to and affect the fluid dynamics This volume responds to the widespread interest among mathematicians biologists and engineers in fluid structure interactions problems Included are expository and review articles in biological fluid dynamics Applications that are considered include ciliary motion upside down jellyfish biological feedback in the kidney peristalsis and dynamic suction pumping and platelet cohesion and adhesion *Exploring Mathematical Modeling in Biology Through Case Studies and Experimental Activities* Rebecca Sanft, Anne Walter, 2020-04-01 Exploring Mathematical Modeling in Biology through Case Studies and Experimental Activities provides supporting materials for courses taken by students majoring in mathematics computer science or in the life sciences The book's cases and lab exercises focus on hypothesis testing and

model development in the context of real data The supporting mathematical coding and biological background permit readers to explore a problem understand assumptions and the meaning of their results The experiential components provide hands on learning both in the lab and on the computer As a beginning text in modeling readers will learn to value the approach and apply competencies in other settings Included case studies focus on building a model to solve a particular biological problem from concept and translation into a mathematical form to validating the parameters testing the quality of the model and finally interpreting the outcome in biological terms The book also shows how particular mathematical approaches are adapted to a variety of problems at multiple biological scales Finally the labs bring the biological problems and the practical issues of collecting data to actually test the model and or adapting the mathematics to the data that can be collected

Lectures Presented at the EU Advanced Workshop on Dynamical Modeling in Biotechnology Franco Bagnoli,Stefano Ruffo,2001 The power of modelization in physics and in engineering is not in doubt while in the biotechnological field many theoretical studies stop at the description level It is time for theoretical modelization to enter the field of biotechnology and that needs people with both physical and biological knowledge This book introduces interested scientists with varied backgrounds to active research in different areas broadly related to what has come to be called dynamical modeling in biology

Dynamic Models of Energy, Robotic, and Biological Systems Jose de Jesus Rubio,Alejandro Zacarias,Jaime Pacheco,2025-05-30 Dynamic models are essential for understanding the system dynamics It is of importance because one mistake in experiments could cause accidents or damages while one mistake in the simulation of dynamic models could cause nothing Each system has a different dynamic model hence this book presents the designs of 10 dynamic models which are mainly classified in two ways The first kind of dynamic models are mainly obtained by the Euler Lagrange method and described by differential equations The second kind of dynamic models are mainly obtained by the neural networks and described by difference equations Topics and features Contains the dynamic models of energy systems Derives dynamic models of energy systems by the Euler Lagrange method Includes the dynamic models of robotic systems Contains the dynamic models of biological systems Derives dynamic models of robotic systems by the Euler Lagrange method Obtains dynamic models of biological systems by neural networks This book is expected to be used primary by researchers and secondary by students and in the areas of control robotics energy biological mechanical mechatronics and computing systems Jose de Jesus Rubio Alejandro Zacarias and Jaime Pacheco are full Professors affiliated with the ESIME Azcapotzalco Instituto Polit cnico Nacional Secci n de Estudios de Posgrado e Investigaci n Ciudad de M xico M xico

Modeling Biological Systems: James W. Haefner,2005-05-06 I Principles 1 1 Models of Systems 3 1 1 Systems Models and Modeling 3 1 2 Uses of Scientific Models 4 1 3 Example Island Biogeography 6 1 4 Classifications of Models 10 1 5 Constraints on Model Structure 12 1 6 Some Terminology 12 1 7 Misuses of Models The Dark Side 13 1 8 Exercises 15 2 The Modeling Process 17 2 1 Models Are Problems 17 2 2 Two Alternative Approaches 18 2 3 An Example Population Doubling Time 24 2 4 Model

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Dynamic Systems Biology Modeling and Simulation

Joseph DiStefano III, 2015-01-10 *Dynamic Systems Biology Modeling and Simulation* consolidates and unifies classical and contemporary multiscale methodologies for mathematical modeling and computer simulation of dynamic biological systems from molecular cellular organ system on up to population levels The book pedagogy is developed as a well annotated systematic tutorial with clearly spelled out and unified nomenclature derived from the author's own modeling efforts publications and teaching over half a century Ambiguities in some concepts and tools are clarified and others are rendered more accessible and practical The latter include novel qualitative theory and methodologies for recognizing dynamical signatures in data using structural multicompartmental and network models and graph theory and analyzing structural and measurement data models for quantification feasibility The level is basic to intermediate with much emphasis on biomodeling from real biodata for use in real applications Introductory coverage of core mathematical concepts such as linear and nonlinear differential and difference equations Laplace transforms linear algebra probability statistics and stochastics topics The pertinent biology biochemistry biophysics or pharmacology for modeling are provided to support understanding the amalgam of math modeling with life sciences Strong emphasis on quantifying as well as building and analyzing biomodels includes methodology and computational tools for parameter identifiability and sensitivity analysis parameter estimation from real data model distinguishability and simplification and practical bioexperiment design and optimization Companion website provides solutions and program code for examples and exercises using Matlab Simulink VisSim SimBiology SAAMII AMIGO Copasi and SBML coded models A full set of PowerPoint slides are available from the author for teaching from his textbook He uses them to teach a 10 week quarter upper division course at UCLA which meets twice a week so there are 20 lectures They can easily be augmented or stretched for a 15 week semester course Importantly the slides are editable so they can be readily adapted to a lecturer's personal style and course content needs The lectures are based on excerpts from 12 of the first 13 chapters of DSBMS They are designed to highlight the key course material as a study guide and structure for students following the full text content The complete PowerPoint slide package 25 MB can be obtained by instructors or prospective instructors by emailing the author directly at joed@cs.ucla.edu

A First Course in Systems Biology Eberhard

Voit,2017-09-05 A First Course in Systems Biology is an introduction for advanced undergraduate and graduate students to the growing field of systems biology Its main focus is the development of computational models and their applications to diverse biological systems The book begins with the fundamentals of modeling then reviews features of the molecular inventories that bring biological systems to life and discusses case studies that represent some of the frontiers in systems biology and synthetic biology In this way it provides the reader with a comprehensive background and access to methods for executing standard systems biology tasks understanding the modern literature and launching into specialized courses or projects that address biological questions using theoretical and computational means New topics in this edition include default modules for model design limit cycles and chaos parameter estimation in Excel model representations of gene regulation through transcription factors derivation of the Michaelis Menten rate law from the original conceptual model different types of inhibition hysteresis a model of differentiation system adaptation to persistent signals nonlinear nullclines PBPK models and elementary modes The format is a combination of instructional text and references to primary literature complemented by sets of small scale exercises that enable hands on experience and large scale often open ended questions for further reflection **Systems Biology and Livestock Science** Marinus te Pas,Henri Woelders,André

Bannink,2011-12-20 Systems Biology is an interdisciplinary approach to the study of life made possible through the explosion of molecular data made available through the genome revolution and the simultaneous development of computational technologies that allow us to interpret these large data sets Systems Biology has changed the way biological science views and studies life and has been implemented in research efforts across the biological sciences Systems Biology and Livestock Science will be the first book to review the latest advances using this research methodology in efforts to improve the efficiency health and quality of livestock production Systems Biology and Livestock Science opens with useful introductory chapters explaining key systems biology principles The chapters then progress to look at specific advances in fields across livestock science Coverage includes but is not limited to chapters on systems biology approaches to animal nutrition reproduction health and disease and animal physiology Written by leading researchers in the field Systems Biology and Livestock Science will be an invaluable resource to researchers professionals and advance students working in this rapidly developing discipline Comprehensive Medicinal Chemistry III ,2017-06-03 Comprehensive Medicinal Chemistry III Eight

Volume Set provides a contemporary and forward looking critical analysis and summary of recent developments emerging trends and recently identified new areas where medicinal chemistry is having an impact The discipline of medicinal chemistry continues to evolve as it adapts to new opportunities and strives to solve new challenges These include drug targeting biomolecular therapeutics development of chemical biology tools data collection and analysis in silico models as predictors for biological properties identification and validation of new targets approaches to quantify target engagement new methods for synthesis of drug candidates such as green chemistry development of novel scaffolds for drug discovery and

the role of regulatory agencies in drug discovery Reviews the strategies technologies principles and applications of modern medicinal chemistry Provides a global and current perspective of today s drug discovery process and discusses the major therapeutic classes and targets Includes a unique collection of case studies and personal assays reviewing the discovery and development of key drugs **NASA Thesaurus** ,1998 Contains the authorized subject terms by which the documents in the NASA STI Database are indexed and retrieved

The book delves into Dynamic Models In Biology. Dynamic Models In Biology is a crucial topic that needs to be grasped by everyone, ranging from students and scholars to the general public. This book will furnish comprehensive and in-depth insights into Dynamic Models In Biology, encompassing both the fundamentals and more intricate discussions.

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 - Chapter 3: Dynamic Models In Biology in Everyday Life
 - Chapter 4: Dynamic Models In Biology in Specific Contexts
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4. In chapter 3, this book will examine the practical applications of Dynamic Models In Biology in daily life. The third chapter will showcase real-world examples of how Dynamic Models In Biology can be effectively utilized in everyday scenarios.
5. In chapter 4, the author will scrutinize the relevance of Dynamic Models In Biology in specific contexts. This chapter will explore how Dynamic Models In Biology is applied in specialized fields, such as education, business, and technology.
6. In chapter 5, this book will draw a conclusion about Dynamic Models In Biology. The final chapter will summarize the key points that have been discussed throughout the book.

This book is crafted in an easy-to-understand language and is complemented by engaging illustrations. It is highly recommended for anyone seeking to gain a comprehensive understanding of Dynamic Models In Biology.

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