

DYNAMICAL MODELS IN BIOLOGY



Miklós Farkas

Dynamical Models In Biology Dynamical Models In Biology

**Vadrevu Sree Hari Rao, Ponnada Raja
Sekhara Rao**



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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

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

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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

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Dynamical models in biology, 1990 **Dynamical Models in Biology** Nicolas Farkas, 2001 **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

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 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

Dynamical Systems for Biological Modeling Fred Brauer, Christopher Kribs, 2015-12-23 Dynamical Systems for Biological Modeling An Introduction prepares both biology and mathematics students with the understanding and techniques necessary to undertake basic modeling of biological systems It achieves this through the development and analysis of dynamical systems The approach emphasizes qualitative ideas rather than explicit computation *Dynamical Systems and Their Applications in Biology* Shigui Ruan, Gail Susan Kohl Wolkowicz, Jianhong Wu, 2003 This volume is based on the proceedings of the International Workshop on Dynamical Systems and their Applications in Biology held at the Canadian Coast Guard College on Cape Breton Island Nova Scotia Canada It presents a broad picture of the current research surrounding applications of dynamical systems in biology particularly in population biology The book contains 19 papers and includes articles on the qualitative and or numerical analysis of models involving ordinary partial functional and stochastic differential equations

Applications include epidemiology population dynamics and physiology The material is suitable for graduate students and research mathematicians interested in ordinary differential equations and their applications in biology Also available by Ruan Wolkowicz and Wu is *Differential Equations with Applications to Biology* Volume 21 in the AMS series Fields Institute Communications *Analysis and Control of Polynomial Dynamic Models with Biological Applications* Gabor Szederkenyi, Attila Magyar, Katalin M. Hangos, 2018-03-30 *Analysis and Control of Polynomial Dynamic Models with Biological Applications* synthesizes three mathematical background areas graphs matrices and optimization to solve problems in the biological sciences in particular dynamic analysis and controller design of QP and polynomial systems arising from predator prey and biochemical models The book puts a significant emphasis on applications focusing on quasi polynomial QP or generalized Lotka Volterra and kinetic systems also called biochemical reaction networks or simply CRNs since they are universal descriptors for smooth nonlinear systems and can represent all important dynamical phenomena that are present in biological and also in general dynamical systems Describes and illustrates the relationship between the dynamical algebraic and structural features of the quasi polynomial QP and kinetic models Shows the applicability of kinetic and QP representation in biological modeling and control through examples and case studies Emphasizes the importance and applicability of quantitative models in understanding and influencing natural phenomena

Systems Biology: Simulation of Dynamic Network States Bernhard Ø. Palsson, 2011-05-26 Biophysical models have been used in biology for decades but they have been limited in scope and size In this book Bernhard Palsson shows how network reconstructions that are based on genomic and bibliomic data and take the form of established stoichiometric matrices can be converted into dynamic models using metabolomic and fluxomic data The Mass Action Stoichiometric Simulation MASS procedure can be used for any cellular process for which data is available and allows a scalable step by step approach to the practical construction of network models Specifically it can treat integrated processes that need explicit accounting of small molecules and protein which allows simulation at the molecular level The material has been class tested by the author at both the undergraduate and graduate level All computations in the text are available online in MATLAB and Mathematica workbooks allowing hands on practice with the material

Formal Methods for Dynamical Systems Marco Bernardo, Erik de Vink, Alessandra Di Pierro, Herbert Wiklicky, 2013-06-12 This book presents 5 tutorial lectures given by leading researchers at the 13th edition of the International School on Formal Methods for the Design of Computer Communication and Software Systems SFM 2013 held in Bertinoro Italy in June 2013 SFM 2013 was devoted to dynamical systems and covered several topics including chaotic dynamics information theory systems biology hybrid systems quantum computing and automata based models and model checking

Dynamical Systems in Population Biology Xiao-Qiang Zhao, 2013-06-05 Population dynamics is an important subject in mathematical biology A central problem is to study the long term behavior of modeling systems Most of these systems are governed by various evolutionary equations such as difference ordinary functional and partial differential

equations see e.g. 165, 142, 218, 119, 55. As we know, interactive populations often live in a fluctuating environment. For example, physical environmental conditions such as temperature and humidity and the availability of food, water, and other resources usually vary in time with seasonal or daily variations. Therefore, more realistic models should be nonautonomous systems. In particular, if the data in a model are periodic functions of time with commensurate period, a periodic system arises if these periodic functions have different minimal periods; we get an almost periodic system. The existing reference books from the dynamical systems point of view mainly focus on autonomous biological systems. The book of Hess [106] is an excellent reference for periodic parabolic boundary value problems with applications to population dynamics. Since the publication of this book, there have been extensive investigations on periodic, asymptotically periodic, almost periodic, and even general nonautonomous biological systems, which in turn have motivated further development of the theory of dynamical systems. In order to explain the dynamical systems approach to periodic population problems, let us consider as an illustration two species periodic competitive systems:

$$\frac{dU_1}{dt} = U_1(U_2 - U_1), \quad \frac{dU_2}{dt} = U_2(U_1 - U_2).$$

Dynamic Models and Control of Biological Systems Vadrevu Sree Hari Rao, Ponnada Raja Sekhara Rao, 2009-08-07. 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.

Dynamic Modeling in Behavioral Ecology Marc Mangel, Colin Whitcomb Clark, 2019-12-31. This book describes a powerful and flexible technique for the modeling of behavior based on evolutionary principles. The technique employs stochastic dynamic programming and permits the analysis of behavioral adaptations wherein organisms respond to changes in their environment and in their own current physiological state. Models can be constructed to reflect sequential decisions concerned simultaneously with foraging, reproduction, predator avoidance, and other activities. The authors show how to construct and use dynamic behavioral models. Part I covers the mathematical background and computer programming, and then uses a paradigm of foraging under risk of predation to exemplify the general modeling technique. Part II consists of five applied chapters illustrating the scope of the dynamic modeling approach. They treat hunting behavior in lions, reproduction in insects, migrations of aquatic organisms, clutch size and parental care in birds, and movement of spiders and raptors. Advanced topics including the study of dynamic evolutionarily stable strategies are discussed in Part III.

Systems Biology and Synthetic Biology Pengcheng Fu, Sven Panke, 2009-08-13. The genomic revolution has opened up systematic investigations and engineering designs for various life forms. Systems biology and synthetic biology are emerging as two complementary approaches which embody the breakthrough in biology and invite application of engineering principles. Systems Biology and Synthetic Biology emphasizes the similarity between biology and engineering at the system level, which is important for applying systems and engineering theories to biology problems. This

book demonstrates to students researchers and industry that systems biology relies on synthetic biology technologies to study biological systems while synthetic biology depends on knowledge obtained from systems biology approaches

Dynamic Process Modeling ,2013-10-02 Inspired by the leading authority in the field the Centre for Process Systems Engineering at Imperial College London this book includes theoretical developments algorithms methodologies and tools in process systems engineering and applications from the chemical energy molecular biomedical and other areas It spans a whole range of length scales seen in manufacturing industries from molecular and nanoscale phenomena to enterprise wide optimization and control As such this will appeal to a broad readership since the topic applies not only to all technical processes but also due to the interdisciplinary expertise required to solve the challenge The ultimate reference work for years to come

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