

DYNAMIC MODELS IN BIOLOGY



STEPHEN P. ELLNER AND
JOHN GUCKENHEIMER



Dynamic Models In Biology

Miklós Farkas



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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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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

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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 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.

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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 **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 Dynamic Systems Biology Modeling and Simulation

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

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Dynamic Models of Infectious Diseases Vadrevu Sree Hari Rao, Ravi Durvasula, 2012-11-07 Despite great advances in public health worldwide insect vector borne infectious diseases remain a leading cause of morbidity and mortality Diseases that are transmitted by arthropods such as mosquitoes sand flies fleas and ticks affect hundreds of millions of people and account for nearly three million deaths all over the world In the past there was very little hope of controlling the epidemics caused by these diseases but modern advancements in science and technology are providing a variety of ways in which these diseases can be handled Clearly the process of transmission of an infectious disease is a nonlinear not necessarily linear dynamic process which can be understood only by appropriately quantifying the vital parameters that govern these dynamics

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

MATHEMATICAL MODELS - Volume III Jerzy A. Filar, Jacek B Krawczyk, 2009-09-19 Mathematical Models is a component of Encyclopedia of Mathematical Sciences in the global Encyclopedia of Life Support Systems EOLSS which is an integrated compendium of twenty one Encyclopedias The Theme on Mathematical Models discusses matters of great relevance to our world such as Basic Principles of Mathematical Modeling Mathematical Models in Water Sciences Mathematical Models in Energy Sciences Mathematical Models of Climate and

Global Change Infiltration and Ponding Mathematical Models of Biology Mathematical Models in Medicine and Public Health Mathematical Models of Society and Development These three volumes are aimed at the following five major target audiences University and College students Educators Professional practitioners Research personnel and Policy analysts managers and decision makers and NGOs

Modeling Dynamic Phenomena in Molecular and Cellular Biology Lee A. Segel, 1984-03-30 The dynamic development of various processes is a central problem of biology and indeed of all the sciences The mathematics describing that development is in general complicated because the models that are realistic are usually nonlinear Consequently many biologists may not notice a possible application of theory They may be unable to decide whether a particular model captures the essence of a system or to appreciate that analysis of a model can reveal important aspects of biological problems and may even describe in detail how a system works The aim of this textbook is to remedy the situation by adopting a general approach to model analysis and applying it several times to problems drawn primarily from molecular and cellular biology of gradually increasing biological and mathematical complexity Although material of considerable sophistication is included little mathematical background is required only some exposure to elementary calculus appendices supply the necessary mathematics and the author concentrates on concepts rather than techniques He also emphasizes the role of computers in giving a full picture of model behavior and complementing more qualitative analysis Some problems suitable for computer analysis are also included This is a class tested textbook suitable for a one semester course for advanced undergraduate and beginning graduate students in biology or applied mathematics It can also be used as a source book for teachers and a reference for specialists

Dynamical models in biology, 1990 [Dynamic Modeling of Diseases and Pests](#) Bruce Hannon, Matthias Ruth, 2008-10-16 The ease of use of the programs in the application to ever more complex cases of disease and pestilence The lack of need on the part of the student or modelers of mathematics beyond algebra and the lack of need of any prior computer programming experience The surprising insights that can be gained from initially simple systems models

Mathematical Modelling with Case Studies B. Barnes, G..R. Fulford, 2014-12-15 Mathematical Modelling with Case Studies Using Maple and MATLAB Third Edition provides students with hands on modelling skills for a wide variety of problems involving differential equations that describe rates of change While the book focuses on growth and decay processes interacting populations and heating cooling problems the mathematical

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

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

Dynamical Models in Biology Nicolas Farkas, 2001 *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

Handbook of Ecological Models used in Ecosystem and Environmental Management Sven Erik Jorgensen, 2016-04-19 It is estimated that roughly 1000 new ecological and environmental models join the ranks of the scientific literature each year The international peer reviewed literature reports some 20 000 new models spanning the period from 1970 2010 Just to keep abreast of the field it is necessary to design a handbook of models that doesn't merely list them

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