

# Lecture Notes in Biomathematics

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Eckart Frehland

Stochastic  
Transport Processes in  
Discrete Biological Systems



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# Stochastic Transport Processes In Discrete Biological Systems

**Johan A. Metz, Odo Diekmann**



## **Stochastic Transport Processes In Discrete Biological Systems:**

Stochastic Transport Processes in Discrete Biological Systems Eckart Frehland, 2013-03-13 These notes are in part based on a course for advanced students in the applications of stochastic processes held in 1978 at the University of Konstanz. These notes contain the results of recent studies on the stochastic description of ion transport through biological membranes. In particular, they serve as an introduction to a unified theory of fluctuations in complex biological transport systems. We emphasize that the subject of this volume is not to introduce the mathematics of stochastic processes but to present a field of theoretical biophysics in which stochastic methods are important. In the last years, the study of membrane noise has become an important method in biophysics. Valuable information on the ion transport mechanisms in membranes can be obtained from noise analysis. A number of different processes such as the opening and closing of ion channels have been shown to be sources of the measured current or voltage fluctuations. Biological transport systems can be complex. For example, the transport process can be coupled to other processes such as chemical reactions and take place in discontinuous structures of molecular dimensions. Furthermore, since there are strong electric fields or high concentration gradients across biological membranes, ion transport processes of biological relevance are mostly processes far from equilibrium. For these reasons, the development of new theoretical concepts has been necessary. The concept of transport in discrete systems has turned out to be more appropriate than continuum models.

Voltage-Sensitive Ion Channels H. Richard Leuchtag, 2008-12-21 The goal of this book is to explore the complexity of a microscopic bit of matter that exists in a myriad of copies within our bodies: the voltage-sensitive ion channel. We seek to investigate the way in which these macromolecules make it possible for the long fibers of our nerve and muscle cells to conduct impulses. These integral components of cell membranes are marvels of nature's evolutionary adaptation. To understand them, we must probe the boundaries of physics and chemistry. Since function is intimately related to structure, we examine the molecular structure of channels, focusing on physical principles that govern all matter. With the application of genetic methods, our knowledge of ion channels has broadened and deepened. In the hope that research can help ameliorate suffering, we discuss the diseases that arise from channel malfunctions due to genetic mutations. This book is intended for students and scientists who are willing to travel into uncharted waters of an interdisciplinary science. We approach the subject of voltage-sensitive ion channels from various points of view. This book seeks to give voice to the viewpoints of the physical and the biological scientist and to bridge gaps in terminology and background. Readers may find this book to have both elementary and advanced aspects. For the reader trained in the biological sciences, it reviews background in physics and chemistry; for the reader trained in the physical sciences, it reviews background in physiology and biochemistry.

Stochastic Methods in Biology Motoo Kimura, Gopinath Kallianpur, Takeyuki Hida, 2013-03-13 The use of probabilistic methods in the biological sciences has been so well established by now that mathematical biology is regarded by many as a distinct discipline with its own repertoire of techniques. The purpose of the Workshop on stochastic methods in

biology held at Nagoya University during the week of July 8-12, 1985 was to enable biologists and probabilists from Japan and the U.S. to discuss the latest developments in their respective fields and to exchange ideas on the applicability of the more recent developments in stochastic process theory to problems in biology. Eighteen papers were presented at the Workshop and have been grouped under the following headings: I Population genetics (five papers), II Measure valued diffusion processes related to population genetics (three papers), III Neurophysiology (two papers), IV Fluctuation in living cells (two papers), V Mathematical methods related to other problems in biology, epidemiology, population dynamics, etc. (six papers). An important feature of the Workshop and one of the reasons for organizing it has been the fact that the theory of stochastic differential equations (SDEs) has found a rich source of new problems in the fields of population genetics and neurobiology. This is especially so for the relatively new and growing area of infinite dimensional i.e. measure valued or distribution valued SDEs. The papers in II and III and some of the papers in the remaining categories represent these areas.

**Applications of Biophotonics and Nanobiomaterials in Biomedical Engineering** Mohammad E. Khosroshahi, 2017-10-30 This book provides a link between different disciplines of nanophysics, biophotonics, nanobiomaterials, applications of nanobiophotonics in biomedical research and engineering. The fundamentals of light-matter, nanobiomaterials, nanophysics are discussed together and relevant applications in biomedical engineering as well as other related factors influencing the interaction process are explicated. Theoretical and experimental research is combined, emphasizing the influence of crucial common factors on applications.

**Biological Motion** Wolfgang Alt, Gerhard Hoffmann, 2013-11-11 Behavior is not what an organism does itself but to what we point. Therefore, whether a type of behavior of an organism is adequate as a certain configuration of movements will depend on the environment in which we describe it.

Humberto Maturana, Francisco Varela, *El árbol del conocimiento* 1984 A thorough analysis of behavior must result in a scheme that shows all regularities that are to be found between the sensorial input and the motorical output of an animal. This scheme is an abstract representation of the brain.

Valentin Braitenberg, *Gehirngespinnste* 1973 During the 70ies when Biomathematics, beyond Biomedical Statistics and Computing, became more popular at universities and research institutes, the problems dealt with came mainly from the general fields of Population Biology and Complex Systems Analysis, such as epidemics, ecosystems, analysis, morphogenesis, genetics, immunology, and neurology. See the first series of Springer Lecture Notes in Biomathematics. Since then, the picture has not considerably changed, and it seems that a thorough analysis of behavior of single organisms and moreover of their mutual interactions is far from being understood. On the contrary, mathematical modellers and analysts have been well advised to restrict their investigations to specific aspects of biological behavior, one of which is biological motion. Until now, only a few Conference Proceedings or Lecture Notes have paid attention to this important aspect, some of the earlier examples being Vol 24: The measurement of biological shape and shape changes, 1978 or Vol *Transient Processes in Cell Proliferation Kinetics* Andrej Yu. Yakovlev, Nikolaj M. Yanev, 2013-03-08 A mathematician who has taken the romantic decision to devote himself to

biology will doubtlessly look upon cell kinetics as the most simple and natural field of application for his knowledge and skills. Indeed the thesaurus he is to master is not so complicated as say in molecular biology the structural elements of the system i.e. cells have been segregated by Nature itself. Simple considerations of balance may be used for deducing basic equations and numerous analogies in other areas of science also superficially add to one's confidence. Generally speaking this number of impressions is correct as evidenced by the very great theoretical studies on population kinetics unmatched in other branches of mathematical biology. This however does not mean that mathematical theory of cell systems has traversed in its development a pathway free of difficulties or errors. The seeming ease of formalizing the phenomena of cell kinetics not infrequently led to the appearance of mathematical models lacking in adequacy or effectiveness from the viewpoint of applications. As in any other domain of science mathematical theory of cell systems has its own intrinsic logic of development which however depends in large measure on the progress in experimental biology. Thus during a fairly long period running into decades activities in that sphere were centered on devising its own specific approaches necessitated by new objectives in the experimental in vivo and in vitro investigation of cell population kinetics in different tissues.

**Current Topics in Membranes and Transport**, 1991-01-18 Current Topics in Membranes and Transport **Synergetics — From Microscopic to Macroscopic Order** E. Frehland, 2012-12-06 This volume contains the papers presented at the International Symposium on Synergetics From Microscopic to Macroscopic Order held at the Wissenschafts kolleg z Berlin Institute for Advanced Study Berlin on July 4-8 1983. Further more it contains a contribution of T Ohta who unfortunately could not participate in this meeting on the evolution of multigene families. The papers discuss the evolution and the function of ordered structures from small microscopic scales up to large macroscopic dimensions. On the one hand these structures derive from physical or biological systems on the other hand they also affect economic sociological and philosophical questions. I would like to thank the Wissenschaftskolleg zu Berlin for the extraordinary support and hospitality during my one year's stay there as a fellow which made the planning preparation and organization of this symposium possible. I would also like to acknowledge the work of B Fritsch and D Dorner who actively participated in this undertaking. I am grateful to Professor Haken the founder of synergetics whose participation in the planning and styling of the concept of the conference was essential. I am especially thankful to Mrs U Monigatti for her indefatigable help with the preparation and organization of the conference. The financial support was provided by the Deutsche Forschungsgemeinschaft Berlin November 1983. E Frehland

**Contents** Some Introductory Remarks on Synergetics By H Haken **Modeling and Management of Resources under Uncertainty** Thomas L. Vincent, Yosef Cohen, Walter J. Grantham, Geoffrey P. Kirkwood, Jan M. Skowronski, 2013-03-08 This volume contains the proceedings of the second U.S. Australia workshop on Renewable Resource Management held at the East West Center Honolulu Hawaii December 9-12 1985. The workshop was jointly sponsored by the National Science Foundation USA and the Department of Science and Technology Australia under the U.S. Australia Cooperative Science

Program The objective of the workshop was to focus on problems associated with the management of renewable resource systems A particular emphasis was given to methods for handling uncertain elements which are present in any real system Toward this end the participants were chosen so that the collective expertise included mathematical modeling dynamical control game theory ecology and practical management of real systems Each participant was invited to give an informal presentation in his field of expertise as related to the overall theme The formal papers contained in this volume were written after the workshop so that the authors could utilize the workshop experience in relating their own work to others To further encourage this exchange each paper contained in this volume was reviewed by two other participants who then wrote formal comments These comments with author's reply in some cases are attached to the end of each paper

*Mathematical Approaches to Problems in Resource Management and Epidemiology* Carlos Castillo-Chavez, Simon A. Levin, Christine A. Shoemaker, 2013-03-08 Increasingly mathematical methods are being used to advantage in addressing the problems facing humanity in managing its environment Problems in resource management and epidemiology especially have demonstrated the utility of quantitative modeling To explore these approaches the Center of Applied Mathematics at Cornell University organized a conference in Fall 1987 with the objective of surveying and assessing the state of the art This volume records the proceedings of that conference Underlying virtually all of these studies are models of population growth from individual cells to large vertebrates Cell population growth presents the simplest of systems for study and is of fundamental importance in its own right for a variety of medical and environmental applications In Part I of this volume Michael Shuler describes computer models of individual cells and cell populations and Frank Hoppensteadt discusses the synchronization of bacterial culture growth Together these provide a valuable introduction to mathematical cell biology

*The Dynamics of Physiologically Structured Populations* Johan A. Metz, Odo Diekmann, 2014-03-11

**Lindenmayer Systems, Fractals, and Plants**

Przemyslaw Prusinkiewicz, James Hanan, 2013-11-11 L-systems are a mathematical formalism which was proposed by Aristid Lindenmayer in 1968 as a foundation for an axiomatic theory of development The notion promptly attracted the attention of computer scientists who investigated L-systems from the viewpoint of formal language theory This theoretical line of research was pursued very actively in the seventies resulting in over one thousand publications A different research direction was taken in 1984 by Alvy Ray Smith who proposed L-systems as a tool for synthesizing realistic images of plants and pointed out the relationship between L-systems and the concept of fractals introduced by Benoit Mandelbrot The work by Smith inspired our studies of the application of L-systems to computer graphics Originally we were interested in two problems Can L-systems be used as a realistic model of plant species found in nature Can L-systems be applied to generate images of a wide class of fractals It turned out that both questions had affirmative answers Subsequently we found that L-systems could be applied to other areas such as the generation of tilings reproduction of a geometric art form from East India and synthesis of musical scores based on an interpretation of fractals This book collects our results related to the graphical applications of

systems It is a corrected version of the notes which we prepared for the ACM SIGGRAPH 88 course on fractals

**Neuronal Noise** Alain Destexhe, Michelle Rudolph-Lilith, 2012-01-07 Neuronal Noise combines experimental theoretical and computational results to show how noise is inherent to neuronal activity and how noise can be important for neuronal computations The book covers many aspects of noise in neurons with an emphasis on the largest source of noise synaptic noise It provides students and young researchers with an overview of the important methods and concepts that have emerged from research in this area It also provides the specialist with a summary of the large body of sometimes contrasting experimental data and different theories proposed to explore the computational power that various forms of noise can confer to neurons

Mathematical Ecology S.A. Levin, T.G. Hallam, 2013-03-13

The Mechanics and Biophysics of Hearing Peter Dallos, C. Daniel Geisler, John W. Matthews, Mario A. Ruggero, Charles R. Steele, 2014-03-11 Proceedings of a workshop on the physics and biophysics of hearing that brought together experimenters and modelers working on all aspects of audition Topics covered include cochlear mechanical measurements cochlear models mechanicals and biophysics of hair cells efferent control and ultrastructure

Mathematical and Statistical Approaches to AIDS Epidemiology Carlos Castillo-Chavez, 2013-03-13 The 18 research articles of this volume discuss the major themes that have emerged from mathematical and statistical research in the epidemiology of HIV The opening paper reviews important recent contributions Five sections follow Statistical Methodology and Forecasting Infectivity and the HIV Heterogeneity and HIV Transmission Dynamics Social Dynamics and AIDS and The Immune System and The HIV In each leading experts in AIDS epidemiology present the recent results Some address the role of variable infectivity heterogeneous mixing and long periods of infectiousness in the dynamics of HIV others concentrate on parameter estimation and short term forecasting The last section looks at the interaction between the HIV and the immune system

**Gonorrhea Transmission Dynamics and Control** H. W. Hethcote, J. A. Yorke, 2014-03-11

*Current Catalog* National Library of Medicine (U.S.), First multi year cumulation covers six years 1965 70

**Population Genetics in Forestry** Hans-Rolf Gregorius, 2013-03-13 When we consider the main object of forestry the tree it immediately becomes clear why experimental population geneticists have been so hesitant in making this object a primary concern of their research Trees are very long living organisms with generation intervals frequently exceeding those of their investigators by multiples They virtually exclude therefore application of the classical methods of population genetics since these are based on observing genetic structures over generations This situation where the limits set to observation are so severe particularly requires close cooperation between theory and experiment It also requires careful consideration of results obtained for organisms other than trees in order to gain additional insights by comparing the results for trees with those for other organisms Yet the greatest challenge to population and ecological genetics probably originates from the fact that forests are very likely to be the most complex ecosystems of all even in some cases where they are subject to intense management This complexity which equally comprises biotic and

abiotic factors varying both in time and space makes extremely high demands on the adaptational capacity and thus flexibility of the carriers of such an ecosystem Longevity combined with immobility during the vegetative phase however appears to contradict the obvious necessity of adaptational flexibility in forest tree populations when compared with short lived and or mobile organisms

### **Acanthaster and the Coral Reef: A Theoretical Perspective** Roger H.

Bradbury, 2013-03-09 In August 1988 the Sixth International Coral Reef Symposium was held in Townsville resulting in an influx of most of the world's coral reef scientists to the city We seized this opportunity at the Australian Institute of Marine Science to run a small workshop immediately before the symposium on the outbreaks of the crown of thorns starfish *Acanthaster planci* We invited that small band of mathematicians who had been modelling the phenomenon and who may not have normally attended an international meeting so thoroughly dedicated to natural science to meet with those scientists who had been actively working on the phenomenon in the field John Casti notes in his delightful new book *Alternate Realities* Wiley 1989 If the natural role of the experimenter is to generate new observables by which we know the processes of Nature and the natural role of the mathematician is to generate new formal structures by which we can represent these processes then the system scientist finds his niche by serving as a broker between the two I think our book shows the fruits of that brokerage through the wide range of models explored within its pages the high level of collaboration and interaction across disciplines evident in the individual papers and in the emerging synthesis that reflects a far deeper understanding of this complex phenomenon than was possible even a few years ago



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