Random Walks In Biology

Chance in Biology
Living at Micro Scale
Classical and Spatial Stochastic Processes
Physical Biology of the Cell
Proving Darwin
Probability on Graphs
Thinking Probabilistically
E. coli in Motion
Mechanics of Motor Proteins and the Cytoskeleton
More Random Walks in Science
A Non-Random Walk Down Wall Street
Molecular and Cellular Biophysics
Cell Movement
Topics in Mathematical Biology
Critical Phenomena in Natural Sciences
Collective Behavior In Systems Biology
Fractional Dynamics
Mathematics of Evolution and Phylogeny
The Physics of Foraging
Life's Ratchet
Variants of Random Walks
From Random Walks to Random Matrices
A Guide to First-Passage Processes
Markov Processes for Stochastic Modeling
First Steps in Random Walks
Stochastic Processes in Cell Biology
First Steps in Random Walks
Physical Models of Living Systems
Non-homogeneous Random Walks
Gibbs Measures in Biology and Physics
Methods of Small Parameter in Mathematical Biology
Random Walks and Diffusion
Random Walks in Biology
The Self-Avoiding Walk
Markov Random Flights
An Introduction to Stochastic Processes with Applications to Biology
What is Life?
Elements of the Random Walk
First Steps in Random Walks
An Immense World

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Chance in Biology Princeton University Press
An Introduction to Stochastic Processes with Applications to Biology, Second Edition presents the basic theory of stochastic processes necessary in understanding and applying stochastic methods to biological problems in areas such as population growth and extinction, drug kinetics, two-species competition and predation, the spread of epidemics, and the genetics of inbreeding. Because of their rich structure, the text focuses on discrete and continuous time Markov chains and continuous time and state Markov processes. New to the Second Edition A new chapter on stochastic differential equations that extends the basic theory to multivariate processes, including multivariate forward and backward Kolmogorov differential equations and the multivariate Itô's formula The inclusion of examples and exercises from cellular and molecular biology Double the number of exercises and MATLAB® programs at the end of each chapter Answers and hints to selected exercises in the appendix Additional references from the literature This edition continues to provide an excellent introduction to the fundamental theory of stochastic processes, along with a wide range of applications from the biological sciences. To better visualize the dynamics of stochastic processes, MATLAB programs are provided in the chapter appendices.
Living at Micro Scale CRC Press
The name "random walk" for a problem of a displacement of a point in a sequence of independent random steps was coined by Karl Pearson in 1905 in a question posed to readers of "Nature". The same year, a similar problem was formulated by Albert Einstein in one of his Annus Mirabilis works. Even earlier such a problem was posed by Louis Bachelier in his thesis devoted to the theory of financial speculations in 1900. Nowadays the theory of random walks has proved useful in physics and chemistry (diffusion, reactions, mixing flows), economics, biology (from animal spread to motion of subcellular structures) and in many other disciplines. The random walk approach serves not only as a model of simple diffusion but of many complex sub- and super-diffusive transport processes as well. This book discusses the main variants of random walks and gives the most important mathematical tools for their theoretical description.
Classical and Spatial Stochastic Processes Springer
Groundbreaking mathematician Gregory Chaitin gives us the first book to posit that we can prove how Darwin's theory of evolution works on a mathematical level. For years it has been received wisdom among most scientists that, just as Darwin claimed, all of the Earth's life-forms evolved by blind chance. But does Darwin's theory function on a purely mathematical level? Has there been enough time for evolution to produce the remarkable biological diversity we see around us? It's a question no one has yet answered—in fact, no one has attempted to answer it until now. In this illuminating and provocative book, Gregory Chaitin elucidates the mathematical scheme he's developed that can explain life itself, and examines the works of mathematical pioneers John von Neumann and Alan Turing through the lens of biology. Fascinating and thought-provoking, Proving Darwin makes clear how biology may have found its greatest ally in mathematics.
Physical Biology of the Cell Cambridge University Press
Escherichia coli, commonly referred to as E. coli, has been the organism of choice for molecular genetics for decades. Its machinery and mobile behavior is one of the most fascinating topics for cell scientists. Scientists and engineers, not trained in microbiology, and who would like to learn more about living machines, can see it as a unique example. This cross-disciplinary monograph covers more than thirty years of research and is accessible to graduate students and scientists alike.
Proving Darwin World Scientific
Life, Hoffman argues, emerges from the random motions of atoms filtered through the sophisticated structures of our evolved machinery. People are essentially giant assemblies of interacting nanoscale machines.
Probability on Graphs CRC Press
More Random Walks in Science is an anthology of fascinating and frequently amusing anecdotes, quotations, illustrations, articles, and reviews that reflect the more lighthearted aspects of the scientific world and the less serious excursions of the scientific mind. The book is guaranteed to delight anyone who has a professional or amateur interest in science.
Thinking Probabilistically Vintage
Stochastic systems provide powerful abstract models for a variety of important real-life applications: for example, power supply, traffic flow, data transmission. They (and the real systems they model) are often subject to phase transitions, behaving in one way when a parameter is below a certain critical value, then switching behaviour as soon as that critical value is reached. In a real system, we do not necessarily have control over all the parameter values, so it is important to know how to find critical points and to understand system behaviour near these points. This book is a modern presentation of the 'semimartingale' or 'Lyapunov function' method applied to near-critical stochastic systems, exemplified by non-homogeneous random walks. Applications treat near-critical stochastic systems and range across modern probability theory from stochastic billiards models to interacting particle systems. Spatially non-homogeneous random walks are explored in depth, as they provide prototypical near-critical systems.
E. coli in Motion Springer
Pross examines these issues from a chemical perspective, providing a new understanding of how the sciences of chemistry and biology relate to one another.
Mechanics of Motor Proteins and the Cytoskeleton Routledge
Please note that the content of this book primarily consists of articles available from Wikipedia or other free sources online. Pages: 24. Chapters: Branching random walk, Brownian motion, Gambler's ruin, Heterogeneous random walk in one dimension, Loop-erased random walk, Ornstein-Uhlenbeck process, Reflected Brownian motion, Wiener process. Excerpt: A random walk is a mathematical formalization of a path that consists of a succession of random steps. For example, the path traced by a molecule as it travels in a liquid or a gas, the search path of a foraging animal, the price of a fluctuating stock and the financial status of a gambler can all be modeled as random walks, although they may not be truly random in reality. The term random walk was first introduced by Karl Pearson in 1905. Random walks have been used in many fields: ecology, economics, psychology, computer science, physics, chemistry, and biology. Random walks explain the observed behaviors of processes in these fields, and thus serve as a fundamental model for the recorded stochastic activity. Various different types of random walks are of interest. Often, random walks are assumed to be Markov chains or Markov processes, but other, more complicated walks are also of interest. Some random walks are on graphs, others on the line, in the plane, or in higher dimensions, while some random walks are on groups. Random walks also vary with regard to the time parameter. Often, the walk is in discrete time, and indexed by the natural numbers, as in . However, some walks take their steps at random times, and in that case the position is defined for the continuum of times . Specific cases or limits of random walks include the Levy flight. Random walks are related to the diffusion models and are a fundamental topic in discussions of Markov processes. Several properties of random walks, including dispersal distributions, first-passage times and encounter rates, have been extensively studied. A popular random...
More Random Walks in Science Cambridge University Press
Advanced biophysics textbook focusing on how physical concepts can be applied to biological problems.
A Non-Random Walk Down Wall Street Springer

Random walks proved to be a useful model of many complex transport processes at the micro and macroscopic level in physics and chemistry, economics, biology and other disciplines. The book discusses the main variants of random walks and gives the most important mathematical tools for their theoretical description.

Molecular and Cellular Biophysics Sinauer

Theoretical physics is a cornerstone of modern physics and provides a foundation for all modern quantitative science. It aims to describe all natural phenomena using mathematical theories and models, and in consequence develops our understanding of the fundamental nature of the universe. This books offers an overview of major areas covering the recent developments in modern theoretical physics. Each chapter introduces a new key topic and develops the discussion in a self-contained manner. At the same time the selected topics have common themes running throughout the book, which connect the independent discussions. The main themes are renormalization group, fixed points, universality, and continuum limit, which open and conclude the work. The development of modern theoretical physics has required important concepts and novel mathematical tools, examples discussed in the book include path and field integrals, the notion of effective quantum or statistical field theories, gauge theories, and the mathematical structure at the basis of the interactions in fundamental particle physics, including quantization problems and anomalies, stochastic dynamical equations, and summation of perturbative series.

Cell Movement Harvard University Press

This book develops the theory of continuous and discrete stochastic processes within the context of cell biology. A wide range of biological topics are covered including normal and anomalous diffusion in complex cellular environments, stochastic ion channels and excitable systems, stochastic calcium signaling, molecular motors, intracellular transport, signal transduction, bacterial chemotaxis, robustness in gene networks, genetic switches and oscillators, cell polarization, polymerization, cellular length control, and branching processes. The book also provides a pedagogical introduction to the theory of stochastic process – Fokker Planck equations, stochastic differential equations, master equations and jump Markov processes, diffusion approximations and the system size expansion, first passage time problems, stochastic hybrid systems, reaction-diffusion equations, exclusion processes, WKB methods, martingales and branching processes, stochastic calculus, and numerical methods. This text is primarily aimed at graduate students and researchers working in mathematical biology and applied mathematicians interested in stochastic modeling. Applied probabilists and theoretical physicists should also find it of interest. It assumes no prior background in statistical physics and introduces concepts in stochastic processes via motivating biological applications. The book is highly illustrated and contains a large number of examples and exercises that further develop the models and ideas in the body of the text. It is based on a course that the author has taught at the University of Utah for many years.

Topics in Mathematical Biology Springer Science & Business Media

A self-avoiding walk is a path on a lattice that does not visit the same site more than once. In spite of this simple definition, many of the most basic questions about this model are difficult to resolve in a mathematically rigorous fashion. In particular, we do not know much about how far an n step self-avoiding walk typically travels from its starting point, or even how many such walks there are. These and other important questions about the self-avoiding walk remain unsolved in the rigorous mathematical sense, although the physics and chemistry communities have reached consensus on the answers by a variety of nonrigorous methods, including computer simulations. But there has been progress among mathematicians as well, much of it in the last decade, and the primary goal of this book is to give an account of the current state of the art as far as rigorous results are concerned. A second goal of this book is to discuss some of the applications of the self-avoiding walk in physics and chemistry, and to describe some of the nonrigorous methods used in those fields. The model originated in chem istry several decades ago as a model for long-chain polymer molecules. Since then it has become an important model in statistical physics, as it exhibits critical behaviour analogous to that occurring in the Ising model and related systems such as percolation.

Critical Phenomena in Natural Sciences Springer Science & Business Media

This book considers evolution at different scales: sequences, genes, gene families, organelles, genomes and species. The focus is on the mathematical and computational tools and concepts, which form an essential basis of evolutionary studies, indicate their limitations, and give them orientation. Recent years have witnessed rapid progress in the mathematics of evolution and phylogeny, with models and methods becoming more realistic, powerful, and complex. Aimed at graduates and researchers in phylogenetics, mathematicians, computer scientists and biologists, and including chapters by leading scientists: A. Bergeron, D. Bertrand, D. Bryant, R. Desper, O. Elemento, N. El-Mabrouk, N. Galtier, O. Gascuel, M. Hendy, S. Holmes, K. Huber, A. Meade, J. Mixtacki, B. Moret, E. Mossel, V. Moulton, M. Pagel, M.-A. Poursat, D. Sankoff, M. Steel, J. Stoye, J. Tang, L.-S. Wang, T. Warnow, Z. Yang, this book of contributed chapters explains the basis and covers the recent results in this highly topical area.

Collective Behavior In Systems Biology Oxford University Press

Markov processes are processes that have limited memory. In particular, their dependence on the past is only through the previous state. They are used to model the behavior of many systems including communications systems, transportation networks, image segmentation and analysis, biological systems and DNA sequence analysis, random atomic motion and diffusion in physics, social mobility, population studies, epidemiology, animal and insect migration, queueing systems, resource management, dams, financial engineering, actuarial science, and decision systems. Covering a wide range of areas of application of Markov processes, this second edition is revised to highlight the most important aspects as well as the most recent trends and applications of Markov processes. The author spent over 16 years in the industry before returning to academia, and he has applied many of the principles covered in this book in multiple research projects. Therefore, this is an applications-oriented book that also includes enough theory to provide a solid ground in the subject for the reader. Presents both the theory and applications of the different aspects of Markov processes Includes numerous solved examples as well as detailed diagrams that make it easier to understand the principle being presented Discusses different applications of hidden Markov models, such as DNA sequence analysis and speech analysis.

Fractional Dynamics Cambridge University Press

This volume provides the latest developments in the field of fractional dynamics, which covers fractional (anomalous) transport phenomena, fractional statistical mechanics, fractional quantum mechanics and fractional quantum field theory. The contributors are selected based on their active and important contributions to their respective topics. This volume is the first of its kind that covers such a comprehensive range of topics in fractional dynamics. It will point out to advanced undergraduate and graduate students, and young researchers the possible directions of research in this subject. In addition to those who intend to work in this field and those already in the field, this volume will also be useful for researchers not directly involved in the field, but want to know the current status and trends of development in this subject. This latter group includes theoretical chemists, mathematical biologists and engineers.

Mathematics of Evolution and Phylogeny Oxford University Press, USA

Life is a chancy proposition: from the movement of molecules to the age at which we die, chance plays a key role in the natural world. Traditionally, biologists have viewed the inevitable "noise" of life as an unfortunate complication. The authors of this book, however, treat random processes as a benefit. In this introduction to chance in biology, Mark Denny and Steven Gaines help readers to apply the probability theory needed to make sense of chance events--using examples from ocean waves to spiderwebs, in fields ranging from molecular mechanics to evolution. Through the application of probability theory, Denny and Gaines make predictions about how plants and animals work in a stochastic universe. Is it possible to pack a variety of ion channels into a cell membrane and have each operate at near-peak flow? Why are our arteries rubbery? The concept of a random walk provides the necessary insight. Is there an absolute upper limit to human life span? Could the sound of a cocktail party burst your eardrums? The statistics of extremes allows us to make the appropriate calculations. How long must you wait to see the detail in a moonlit landscape? Can you hear the noise of individual molecules? The authors provide answers to these and many other questions. After an introduction to the basic statistical methods to be used in this book, the authors emphasize the application of probability theory to biology rather than the details of the theory itself. Readers with an introductory background in calculus will be able to follow the reasoning, and sets of problems, together with their solutions, are offered to reinforce concepts. The use of real-world examples, numerous illustrations, and chapter summaries--all presented with clarity and wit--make for a highly accessible text. By relating the theory of probability to the understanding of form and function in living things, the authors seek to pique the reader's curiosity about statistics and provide a new perspective on the role of chance in biology.

The Physics of Foraging Newnes

Random walks have proven to be a useful model in understanding processes across a wide spectrum of scientific disciplines. Elements of the Random Walk is an introduction to some of the most powerful and general techniques used in the application of these ideas. The mathematical construct that runs through the analysis of the topics covered in this book, unifying the mathematical treatment, is the generating function. Although the reader is introduced to analytical tools, such as path-integrals and field-theoretical formalism, the book is self-contained in that basic concepts are developed and relevant fundamental findings fully discussed. Mathematical background is provided in supplements at the end of each chapter, when appropriate. This text will appeal to graduate students across science, engineering and mathematics who need to understand the applications of random walk techniques, as well as to established researchers.

Life's Ratchet Cambridge University Press

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.