

Modeling In The Neurosciences From Ionic Channels

[#Neuroscience modeling](#) [#Ionic channel biophysics](#) [#Computational neuroscience](#) [#Neural simulation](#) [#Ion channel models](#)

Explore the critical role of modeling in the neurosciences, specifically focusing on how detailed ionic channel modeling provides fundamental insights into neuronal excitability and signal transduction. This interdisciplinary field of computational neuroscience is essential for understanding complex brain functions and developing new therapeutic strategies.

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Modeling in the Neurosciences

With contributions from more than 40 renowned experts, Modeling in the Neurosciences: From Ionic Channels to Neural Networks is essential for those interested in neuronal modeling and quantitative neuroscience. Focusing on new mathematical and computer models, techniques and methods, this monograph represents a cohesive and comprehensive treatment

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Methods in Neuronal Modeling

Kinetic Models of Synaptic Transmission / Alain Destexhe, Zachary F. Mainen, Terrence J. Sejnowski / - Cable Theory for Dendritic Neurons / Wilfrid Rall, Hagai Agmon-Snir / - Compartmental Models of Complex Neurons / Idan Segev, Robert E. Burke / - Multiple Channels and Calcium Dynamics / Walter M. Yamada, Christof Koch, Paul R. Adams / - Modeling Active Dendritic Processes in Pyramidal Neurons / Zachary F. Mainen, Terrence J. Sejnowski / - Calcium Dynamics in Large Neuronal Models / Erik De Schutter, Paul Smolen / - Analysis of Neural Excitability and Oscillations / John Rinzel, Bard Ermentrout / - Design and Fabrication of Analog VLSI Neurons / Rodney Douglas, Misha Mahowald / - Principles of Spike Train Analysis / Fabrizio Gabbiani, Christof Koch / - Modeling Small Networks / Larry Abbott, Eve Marder / - Spatial and Temporal Processing in Central Auditory Networks / Shihab Shamma / - Simulating Large Networks of Neurons / Alexander D. Protopapas, Michael Vanier, James M. Bower / ...

Modeling in the Neurosciences

Computational models of neural networks have proven insufficient to accurately model brain function, mainly as a result of simplifications that ignore the physical reality of neuronal structure in favor of mathematically tractable algorithms and rules. Even the more biologically based "integrate and fire" and "compartmental" styles of modeling suff

Principles of Computational Modelling in Neuroscience

The nervous system is made up of a large number of interacting elements. To understand how such a complex system functions requires the construction and analysis of computational models at many different levels. This book provides a step-by-step account of how to model the neuron and neural circuitry to understand the nervous system at all levels, from ion channels to networks. Starting with a simple model of the neuron as an electrical circuit, gradually more details are added to include the effects of neuronal morphology, synapses, ion channels and intracellular signalling. The principle of abstraction is explained through chapters on simplifying models, and how simplified models can be used in networks. This theme is continued in a final chapter on modelling the development of the nervous system. Requiring an elementary background in neuroscience and some high school mathematics, this textbook is an ideal basis for a course on computational neuroscience.

Computational Modelling of the Brain

This volume offers an up-to-date overview of essential concepts and modern approaches to computational modelling, including the use of experimental techniques related to or directly inspired by them. The book introduces, at increasing levels of complexity and with the non-specialist in mind, state-of-the-art topics ranging from single-cell and molecular descriptions to circuits and networks. Four major themes are covered, including subcellular modelling of ion channels and signalling pathways at the molecular level, single-cell modelling at different levels of spatial complexity, network modelling from local microcircuits to large-scale simulations of entire brain areas and practical examples. Each chapter presents a systematic overview of a specific topic and provides the reader with the fundamental tools needed to understand the computational modelling of neural dynamics. This book is aimed at experimenters and graduate students with little or no prior knowledge of modelling who are interested in learning about computational models from the single molecule to the inter-areal communication of brain structures. The book will appeal to computational neuroscientists, engineers, physicists and mathematicians interested in contributing to the field of neuroscience. Chapters 6, 10 and 11 are available open access under a Creative Commons Attribution 4.0 International License via link.springer.com.

Computational Neuroscience

Progress in Molecular Biology and Translational Science provides a forum for discussion of new discoveries, approaches, and ideas in molecular biology. It contains contributions from leaders in their fields and abundant references. This volume brings together different aspects of, and approaches to, molecular and multi-scale modeling, with applications to a diverse range of neurological diseases. Mathematical and computational modeling offers a powerful approach for examining the interaction between molecular pathways and ionic channels in producing neuron electrical activity. It is well accepted that non-linear interactions among diverse ionic channels can produce unexpected neuron behavior and hinder a deep understanding of how ion channel mutations bring about abnormal behavior and disease. Interactions with the diverse signaling pathways activated by G protein coupled receptors or calcium influx adds an additional level of complexity. Modeling is an approach to integrate myriad data sources into a cohesive and quantitative model in order to evaluate hypotheses about neuron function. In particular, a validated model developed using in vitro data allows simulations of the response to in vivo like spatio-temporal patterns of synaptic input. Incorporating molecular signaling pathways into an electrical model, allows a greater range of models to be developed, ones that can predict the response to pharmaceuticals, many of which target neuromodulator pathways. Contributions from leading authorities Informs and updates on all the latest developments in the field

Principles of Computational Modelling in Neuroscience

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Computational Neuroscience

Designed primarily as an introduction to realistic modeling methods, Computational Neuroscience: Realistic Modeling for Experimentalists focuses on methodological approaches, selecting appropriate methods, and identifying potential pitfalls. The author addresses varying levels of complexity, from molecular interactions within single neurons to the processing of information by neural networks. He avoids theoretical mathematics and provides just enough of the basic math used by experimentalists. What makes this resource unique is the inclusion of downloadable resources that furnish interactive modeling examples. It contains tutorials and demos, movies and images, and the simulation scripts necessary to run the full simulation described in the chapter examples. Each chapter covers: the theoretical foundation; parameters needed; appropriate software descriptions; evaluation of the model; future directions expected; examples in text boxes linked to the downloadable resources; and references. The first book to bring you cutting-edge developments in neuronal modeling. It provides an introduction to realistic modeling methods at levels of complexity varying from molecular interactions to neural networks. The book and downloadable resources combine to make Computational Neuroscience: Realistic Modeling for Experimentalists the complete package for understanding modeling techniques.

Computational Systems Neurobiology

Computational neurosciences and systems biology are among the main domains of life science research where mathematical modeling made a difference. This book introduces the many different types of computational studies one can develop to study neuronal systems. It is aimed at undergraduate students starting their research in computational neurobiology or more senior researchers who would like, or need, to move towards computational approaches. Based on their specific project, the readers would then move to one of the more specialized excellent textbooks available in the field. The first part of the book deals with molecular systems biology. Functional genomics is introduced through examples of transcriptomics and proteomics studies of neurobiological interest. Quantitative modelling of biochemical systems is presented in homogeneous compartments and using spatial descriptions. A second part deals with the various approaches to model single neuron physiology, and naturally moves to neuronal networks. A division is focused on the development of neurons and neuronal systems and the book closes on a series of methodological chapters. From the molecules to the organ, thinking at the level of systems is transforming biology and its impact on society. This book will help the reader to hop on the train directly in the tank engine.

Textbook of Ion Channels Volume I

The Textbook of Ion Channels is a set of three volumes providing a wide-ranging reference source on ion channels for students, instructors and researchers. Ion channels are membrane proteins that control the electrical properties of neurons and cardiac cells; mediate the detection and response to sensory stimuli like light, sound, odor, and taste; and regulate the response to physical stimuli like temperature and pressure. In non-excitable tissues, ion channels are instrumental for the regulation of basic salt balance that is critical for homeostasis. Ion channels are located at the surface membrane of cells, giving them the unique ability to communicate with the environment, as well as the membrane of intracellular organelles, allowing them to regulate internal homeostasis. Ion channels are fundamentally important for human health and diseases, and are important targets for pharmaceuticals in mental illness, heart disease, anesthesia, pain and other clinical applications. The modern methods used in their study are powerful and diverse, ranging from single ion-channel measurement techniques to models of ion channel diseases in animals, and human clinical trials for ion channel drugs. Volume I, Part 1 covers fundamental topics such as the basic principles of ion permeation and selectivity, voltage-dependent, ligand-dependent, and mechano-dependent ion channel activation mechanisms, the mechanisms for ion channel desensitization and inactivation, and basic ion channel pharmacology and inhibition. Volume I, Part 2 offers a practical guide of cardinal methods for researching ion channels, including heterologous expression and voltage-clamp and patch-clamp electrophysiology; isolation of native currents using patch clamping; modeling ion channel gating, structures, and its dynamics; crystallography and cryo-electron microscopy; fluorescence and paramagnetic resonance spectroscopy methods; and genetics approaches in model organisms. All three volumes give the reader an introduction to fundamental concepts needed to understand the mechanism of ion channels; a guide to the technical aspects of ion channel research; a modern guide to the properties of major ion channel families; and includes coverage of key examples of regulatory, physiological and disease roles for ion channels.

Methods in Neuronal Modeling, second edition

Much research focuses on the question of how information is processed in nervous systems, from the level of individual ionic channels to large-scale neuronal networks, and from "simple" animals such as sea slugs and flies to cats and primates. New interdisciplinary methodologies combine a bottom-up experimental methodology with the more top-down-driven computational and modeling approach. This book serves as a handbook of computational methods and techniques for modeling the functional properties of single and groups of nerve cells. The contributors highlight several key trends: (1) the tightening link between analytical/numerical models and the associated experimental data, (2) the broadening of modeling methods, at both the subcellular level and the level of large neuronal networks that incorporate real biophysical properties of neurons as well as the statistical properties of spike trains, and (3) the organization of the data gained by physical emulation of the nervous system components through the use of very large scale circuit integration (VLSI) technology. The field of neuroscience has grown dramatically since the first edition of this book was published nine years ago. Half of the chapters of the second edition are completely new; the remaining ones have all been thoroughly revised. Many chapters provide an opportunity for interactive tutorials and simulation programs. They can be accessed via Christof Koch's Website. Contributors Larry F. Abbott, Paul R. Adams, Hagai Agmon-Snir, James M. Bower, Robert E. Burke, Erik de Schutter, Alain Destexhe, Rodney Douglas, Bard Ermentrout, Fabrizio Gabbiani, David Hansel, Michael Hines, Christof Koch, Misha Mahowald, Zachary F. Mainen, Eve Marder, Michael V. Maccagni, Alexander D. Protopapas, Wilfrid Rall, John Rinzel, Idan Segev, Terrence J. Sejnowski, Shihab Shamma, Arthur S. Sherman, Paul Smolen, Haim Sompolinsky, Michael Vanier, Walter M. Yamada

Principles of Computational Modelling in Neuroscience

Learn to use computational modelling techniques to understand the nervous system at all levels, from ion channels to networks.

Methods in Neuronal Modeling

Methods in Neuronal Modeling is the first technical handbook on computational neuroscience. Written for researchers and theoreticians alike, it outlines methods and techniques used for simulating on digital computers the functional properties of single neurons from synapses, dendrites, single cells; and small invertebrate networks to large scale neural networks in the mammalian nervous system. The use of new experimental tools such as selective staining methods, membrane patch electrodes,

voltage and calcium-dependent dyes, and multielectrode recordings, together with the, advent of universally available powerful computing, makes it possible to construct detailed and realistic models of neuronal systems. *Methods in Neuronal Modeling* addresses such questions as what can and should be simulated and what techniques should be used; what experimental parameters are crucial for such simulations, and whether these models may be verified experimentally. Chapters cover simulation of passive dendritic trees, compartmental models of single cells including neurons with a number of different ionic channels, calcium current dynamics, simulations of small invertebrate networks, simulations of the mammalian cortex, connectionists' models, and the use of parallel computers in modeling neural networks. Although the chapters were written by several authors, they are uniform in structure and notation. Detailed examples are given to clarify the different approaches. Each chapter concludes with a description of the model discussed and the details of its implementation on the computer. Christof Koch is an Assistant Professor of Computation and Neural Systems at the California Institute of Technology. Idan Segev is a Lecturer in Neurobiology at the Institute of Life Science, Hebrew University of Jerusalem. *Methods in Neuronal Modeling* inaugurates the new series in Computational Neuroscience, edited by Terrence J. Sejnowski and Tomaso Poggio. A Bradford Book.

Spiking Neuron Models

This is an introduction to spiking neurons for advanced undergraduate or graduate students. It can be used with courses in computational neuroscience, theoretical biology, neural modeling, biophysics, or neural networks. It focuses on phenomenological approaches rather than detailed models in order to provide the reader with a conceptual framework. No prior knowledge beyond undergraduate mathematics is necessary to follow the book. Thus it should appeal to students or researchers in physics, mathematics, or computer science interested in biology; moreover it will also be useful for biologists working in mathematical modeling.

Computational Neuroendocrinology

Neuroendocrinology with its well defined functions, inputs, and outputs, is one of the most fertile grounds for computational modeling in neuroscience. But modeling is often seen as something of a dark art. This book aims to display the power of modeling approaches in neuroendocrinology, and to showcase its potential for understanding these complex systems. A recurring theme in neuroendocrinology is rhythms. How are rhythms generated, and what purpose do they serve? Are these two questions inextricably intertwined? This book is written for innocents, presuming no math beyond high school or computing beyond calculators. It seeks to lead the curious into the thinking of the modeler, providing the tools to the reader to understand models, and even develop their own, giving life to paper diagrams. The diverse chapters, from ion channels to networks, systems, and hormonal rhythms, each tell the story of a model serving to join the hard won dots of experimentation, mapping a new understanding, and revealing hidden knowledge. • Written by a team of internationally renowned researchers • Both print and enhanced e-book versions are available • Illustrated in full colour throughout This is the fourth volume in a new Series 'Masterclass in Neuroendocrinology', a co- publication between Wiley and the INF (International Neuroendocrine Federation) that aims to illustrate highest standards and encourage the use of the latest technologies in basic and clinical research and hopes to provide inspiration for further exploration into the exciting field of neuroendocrinology. Series Editors: John A. Russell, University of Edinburgh, UK and William E. Armstrong, The University of Tennessee, USA • Written by a team of internationally renowned researchers • Both print and enhanced e-book versions are available • Illustrated in full colour throughout This is the fourth volume in a new Series 'Masterclass in Neuroendocrinology', a co- publication between Wiley and the INF (International Neuroendocrine Federation) that aims to illustrate highest standards and encourage the use of the latest technologies in basic and clinical research and hopes to provide inspiration for further exploration into the exciting field of neuroendocrinology. Series Editors: John A. Russell, University of Edinburgh, UK and William E. Armstrong, The University of Tennessee, USA

Stochastic Methods in Neuroscience

Computational or mathematical neuroscience is a research area currently of great interest, due to, amongst other factors, rapid increases in computing power, increases in the ability to record large amounts of neurophysiological data, and a realisation amongst both neuroscientists and mathematicians that each can benefit from collaborating with the other. Suitable for graduates and researchers in computational neuroscience, stochastic systems, and neuroscientists seeking to learn more about

recent advances in the modelling and analysis of noisy neural systems, this text presents an overview of neuroscience and the role of noise via a series of self-contained chapters on major aspects, written by experts in their particular field. These range over Markov chain models for ion channel release, stochastically forced single neurons and population of neurons, statistical methods for parameter estimation, and the numerical approximation these models. Each chapter will give an overview of a particular topic, including its history, important results in the area, and future challenges.

Computational Neuroscience

Designed primarily as an introduction to realistic modeling methods, *Computational Neuroscience: Realistic Modeling for Experimentalists* focuses on methodological approaches, selecting appropriate methods, and identifying potential pitfalls. The author addresses varying levels of complexity, from molecular interactions within single neurons to the

Post-Genomic Perspectives in Modeling and Control of Breathing

Post Genomic Perspectives in Modeling and Control of Breathing is comprised of the proceedings of the IXth Oxford Conference on Modeling and Control of Breathing, held September 13-16, 2003 in Paris, France. This publication is placed within the general framework of post-genomic neurobiology, pathology, and the precise example of the rhythmic respiratory neural assembly being used to understand how genetic networks have been selected and conserved in the vertebrate brain. Specific topics include: ion channels and synapses responsible for respiratory rhythmogenesis and plasticity; pre- and post-natal development of the respiratory rhythm; chemosensory transduction and chemo-afferent signalling. These valuable insights open new avenues as to why the genetic codes underlying a vital function such as breathing have been selected, conserved, or optimized during evolution – a major issue of post-genomic biology. This critical issue will be considered from both top-down and bottom-up integrative modeling standpoints, with a view to elucidating the functional genomics linking discrete molecules to the integrated system that regulates breathing.

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Model Neural Networks and Behavior

The most conspicuous function of the nervous system is to control animal behavior. From the complex operations of learning and mentation to the molecular configuration of ionic channels, the nervous system serves as the interface between an animal and its environment. To study and understand the

fundamental mechanisms underlying the control of behavior, it is often both necessary and desirable to employ biological systems with characteristics especially suitable for answering specific questions. In neurobiology, many invertebrates have become established as model systems for investigations at both the systems and the cellular level. Large, readily identifiable neurons have made invertebrates especially useful for cellular studies. The fact that these neurons occur in much smaller numbers than those in higher animals also makes them important for circuit analysis. Although important differences exist, some of the questions that would be technically impossible to answer with vertebrates can become experimentally tractable with invertebrates.

Neuronal Stochastic Variability: Influences on Spiking Dynamics and Network Activity

Stochastic fluctuations are intrinsic to and unavoidable at every stage of neural dynamics. For example, ion channels undergo random conformational changes, neurotransmitter release at synapses is discrete and probabilistic, and neural networks are embedded in spontaneous background activity. The mathematical and computational tool sets contributing to our understanding of stochastic neural dynamics have expanded rapidly in recent years. New theories have emerged detailing the dynamics and computational power of the balanced state in recurrent networks. At the cellular level, novel stochastic extensions to the classical Hodgkin-Huxley model have enlarged our understanding of neuronal dynamics and action potential initiation. Analytical methods have been developed that allow for the calculation of the firing statistics of simplified phenomenological integrate-and-fire models, taking into account adaptation currents or temporal correlations of the noise. This Research Topic is focused on identified physiological/internal noise sources and mechanisms. By "internal"

Computational Neuroscience: Trends in Research 2004

The CNS meetings bring together computational neuroscientists representing many different fields and backgrounds as well as many different experimental preparations and theoretical approaches. The papers published here range from pure experimental neurobiology, to neuro-ethology, mathematics, physics, and engineering. In all cases the research described is focused on understanding how nervous systems compute. The actual subjects of the research include a highly diverse number of preparations, modeling approaches and analysis techniques. Accordingly, this volume reflects the breadth and depth of current research in computational neuroscience taking place throughout the world.

Ion Channel Diseases

Ion channel dysfunction in humans leads to impairment of the excitable processes necessary for the normal function of several tissues, such as muscle and brain. It follows that an increasing number of human diseases have been associated with malfunctioning ion channels, many of which have a genetic component. This volume of *Advances in Genetics* presents a broad and comprehensive overview of the inherited channelopathies in humans, including clinical, genetic and molecular aspects of these conditions. Keeping true to the scope of the series, novel genomic and modeling research approaches and a review of potential therapeutic approaches for each of these conditions are also incorporated.

Modeling Neural Development

An important collection showing how computational and mathematical modeling can be used to study the complexities of neural development.

Biophysics of Computation

Neural network research often builds on the fiction that neurons are simple linear threshold units, completely neglecting the highly dynamic and complex nature of synapses, dendrites, and voltage-dependent ionic currents. *Biophysics of Computation: Information Processing in Single Neurons* challenges this notion, using richly detailed experimental and theoretical findings from cellular biophysics to explain the repertoire of computational functions available to single neurons. The author shows how individual nerve cells can multiply, integrate, or delay synaptic inputs and how information can be encoded in the voltage across the membrane, in the intracellular calcium concentration, or in the timing of individual spikes. Key topics covered include the linear cable equation; cable theory as applied to passive dendritic trees and dendritic spines; chemical and electrical synapses and how to treat them from a computational point of view; nonlinear interactions of synaptic input in passive and active dendritic trees; the Hodgkin-Huxley model of action potential generation and propagation; phase space

analysis; linking stochastic ionic channels to membrane-dependent currents; calcium and potassium currents and their role in information processing; the role of diffusion, buffering and binding of calcium, and other messenger systems in information processing and storage; short- and long-term models of synaptic plasticity; simplified models of single cells; stochastic aspects of neuronal firing; the nature of the neuronal code; and unconventional models of sub-cellular computation. *Biophysics of Computation: Information Processing in Single Neurons* serves as an ideal text for advanced undergraduate and graduate courses in cellular biophysics, computational neuroscience, and neural networks, and will appeal to students and professionals in neuroscience, electrical and computer engineering, and physics.

Computational Neuroscience

This volume includes papers originally presented at the 7th annual Computational Neuroscience Meeting (CNS'98) held in July of 1998 at the Fess Parker Doubletree Inn in Santa Barbara, California. The CNS meetings bring together computational neuroscientists representing many different fields and backgrounds as well as many different experimental preparations and theoretical approaches. The papers published here range from pure experimental neurobiology, to neuro-ethology, mathematics, physics, and engineering. In all cases the research described is focused on understanding how nervous systems compute. The actual subjects of the research include a highly diverse number of preparations, modeling approaches, and analysis techniques. Accordingly, this volume reflects the breadth and depth of current research in computational neuroscience taking place throughout the world.

New Strategies in Stroke Intervention

Ischemic brain damage represents a major source of morbidity and mortality in westernized society and poses a significant financial burden on the health care system. To date, few effective therapies have been realized. Recent evidence, however, suggests that channels, pumps, and ionic exchangers are involved in CNS ischemia and ischemic stroke, but the potential contribution of these channels for curing stroke is far less understood than for many other normal and pathological conditions. *New Strategies in Stroke Intervention: Ionic Channels, Pumps, and Transporters*, analyzes the roles played by targets in stroke development and the potential action of drugs modulating these proteins. This book provides a groundbreaking review of these ionic channels, pumps, and transporters as regulators of neuronal ionic homeostasis, providing a better understanding of ischemic brain disorders and the new pharmacological avenues for a cure.

From Computer to Brain

Biology undergraduates, medical students and life-science graduate students often have limited mathematical skills. Similarly, physics, math and engineering students have little patience for the detailed facts that make up much of biological knowledge. Teaching computational neuroscience as an integrated discipline requires that both groups be brought forward onto common ground. This book does this by making ancillary material available in an appendix and providing basic explanations without becoming bogged down in unnecessary details. The book will be suitable for undergraduates and beginning graduate students taking a computational neuroscience course and also to anyone with an interest in the uses of the computer in modeling the nervous system.

Nonclassical Ion Channels in the Nervous System

Ion channels generate bioelectricity. Recent findings have documented the biophysical properties, the structure, assembly and regulation, and function and dysfunction of nonclassical nervous system ion channels. This book reviews nonclassical ion channel research, ranging from the basic biology, structure, regulations to their functions not only in normal physiology but also neurological disorders, using a variety of cutting-edge techniques and novel animal models.

Using The Biological Literature

"Provides an in-depth review of current print and electronic tools for research in numerous disciplines of biology, including dictionaries and encyclopedias, method guides, handbooks, on-line directories, and periodicals. Directs readers to an associated Web page that maintains the URLs and annotations of all major Internet resources discussed in th

An Introduction to Neural Information Processing

This book provides an overview of neural information processing research, which is one of the most important branches of neuroscience today. Neural information processing is an interdisciplinary subject, and the merging interaction between neuroscience and mathematics, physics, as well as information science plays a key role in the development of this field. This book begins with the anatomy of the central nervous system, followed by an introduction to various information processing models at different levels. The authors all have extensive experience in mathematics, physics and biomedical engineering, and have worked in this multidisciplinary area for a number of years. They present classical examples of how the pioneers in this field used theoretical analysis, mathematical modeling and computer simulation to solve neurobiological problems, and share their experiences and lessons learned. The book is intended for researchers and students with a mathematics, physics or informatics background who are interested in brain research and keen to understand the necessary neurobiology and how they can use their specialties to address neurobiological problems. It also provides inspiration for neuroscience students who are interested in learning how to use mathematics, physics or informatics approaches to solve problems in their field.

Handbook of Ion Channels

The New Benchmark for Understanding the Latest Developments of Ion Channels Ion channels control the electrical properties of neurons and cardiac cells, mediate the detection and response to sensory stimuli, and regulate the response to physical stimuli. They can often interact with the cellular environment due to their location at the surface of cells. In nonexcitable tissues, they also help regulate basic salt balance critical for homeostasis. All of these features make ion channels important targets for pharmaceuticals. Handbook of Ion Channels illustrates the fundamental importance of these membrane proteins to human health and disease. Renowned researchers from around the world introduce the technical aspects of ion channel research, provide a modern guide to the properties of major ion channels, and present powerful methods for modeling ion channel diseases and performing clinical trials for ion channel drugs. Conveniently divided into five parts, the handbook first describes the basic concepts of permeation and gating mechanisms, balancing classic theories and the latest developments. The second part covers the principles and practical issues of both traditional and new ion channel techniques and their applications to channel research. The third part organizes the material to follow the superfamilies of ion channels. This part focuses on the classification, properties, gating mechanisms, function, and pharmacology of established and novel channel types. The fourth part addresses ion channel regulation as well as trafficking and distribution. The final part examines several ion channel-related diseases, discussing genetics, mechanisms, and pharmaceutical advances.

Modeling Neural Circuits Made Simple with Python

An accessible undergraduate textbook in computational neuroscience that provides an introduction to the mathematical and computational modeling of neurons and networks of neurons. Understanding the brain is a major frontier of modern science. Given the complexity of neural circuits, advancing that understanding requires mathematical and computational approaches. This accessible undergraduate textbook in computational neuroscience provides an introduction to the mathematical and computational modeling of neurons and networks of neurons. Starting with the biophysics of single neurons, Robert Rosenbaum incrementally builds to explanations of neural coding, learning, and the relationship between biological and artificial neural networks. Examples with real neural data demonstrate how computational models can be used to understand phenomena observed in neural recordings. Based on years of classroom experience, the material has been carefully streamlined to provide all the content needed to build a foundation for modeling neural circuits in a one-semester course. Proven in the classroom Example-rich, student-friendly approach Includes Python code and a mathematical appendix reviewing the requisite background in calculus, linear algebra, and probability Ideal for engineering, science, and mathematics majors and for self-study

Textbook of Ion Channels: Properties, function, and pharmacology of the superfamilies

"From the editors of the renowned Handbook of Ion Channels, Textbook of Ion Channels is a student-friendly, advanced textbook that illustrates the fundamental importance of these membrane proteins to human health and disease. It has been split into three separate volumes so that each volume can target different needs. The basic concepts of ion channel research are introduced in the first volume, whilst volume two focuses on the pharmacology of ion channels' superfamilies, and volume

three presents powerful methods for modeling ion channel diseases and performing clinical trials for ion channel drugs"--

Reproducibility and Rigour in Computational Neuroscience

Quantitative Neurophysiology is supplementary text for a junior or senior level course in neuro-engineering. It may also serve as a quick-start for graduate students in engineering, physics or neuroscience as well as for faculty interested in becoming familiar with the basics of quantitative neuroscience. The first chapter is a review of the structure of the neuron and anatomy of the brain. Chapters 2-6 derive the theory of active and passive membranes, electrical propagation in axons and dendrites and the dynamics of the synapse. Chapter 7 is an introduction to modeling networks of neurons and artificial neural networks. Chapter 8 and 9 address the recording and decoding of extracellular potentials. The final chapter has descriptions of a number of more advanced or new topics in neuroengineering. Throughout the text, vocabulary is introduced which will enable students to read more advanced literature and communicate with other scientists and engineers working in the neurosciences. Numerical methods are outlined so students with programming knowledge can implement the models presented in the text. Analogies are used to clarify topics and reinforce key concepts. Finally, homework and simulation problems are available at the end of each chapter.

Quantitative Neurophysiology

This book contains twenty-two original contributions that provide a comprehensive overview of computational approaches to understanding a single neuron structure. The focus on cellular-level processes is twofold. From a computational neuroscience perspective, a thorough understanding of the information processing performed by single neurons leads to an understanding of circuit- and systems-level activity. From the standpoint of artificial neural networks (ANNs), a single real neuron is as complex an operational unit as an entire ANN, and formalizing the complex computations performed by real neurons is essential to the design of enhanced processor elements for use in the next generation of ANNs. The book covers computation in dendrites and spines, computational aspects of ion channels, synapses, patterned discharge and multistate neurons, and stochastic models of neuron dynamics. It is the most up-to-date presentation of biophysical and computational methods.

Single Neuron Computation