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.

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Neurophysiological Techniques, I Basic Methods and Concepts, Alan A. Boulton, Glen B. Baker, Case H. Vanderwolf, 1990, Medical, 394 pages. The latest information and methodologies for studying the activity of living nervous tissue, with special emphasis on electrophysiological techniques and their applications.

The book of GENESIS exploring realistic neural models with the GEneral NEural SImulation System, James M. Bower, David Beeman, 1995, Computers, 409 pages. This title introduces and guides the reader through Genesis, a simulation and modeling software tool that is delivered on-line via the Internet from a California Institute of.

Evolving Brains , John Allman, Mar 27, 2000, Medical, 224 pages. Drawing on a wealth of new findings in molecular genetics and paleontology, "Evolving Brains" reveals many of the underlying physiological mechanisms that have influenced the.

The Dappled World A Study of the Boundaries of Science, Nancy Cartwright, Sep 23, 1999, Philosophy, 247 pages. This important and innovative collection of essays argues for a patchwork of laws of nature.

Molecular and Cellular Physiology of Neurons , Gordon L. Fain, 1999, Medical, 693 pages. In order to understand the brain, you must understand how the individual molecules and cells of the nervous system function and ultimately contribute to human behaviour. This.

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Computational Neuroscience Trends in Research 2004, E. De Schutter, Erik De Schutter, 2004, Science, 1228 pages. The CNS meetings bring together computational neuroscientists representing many different fields and backgrounds as well as many different experimental preparations and.
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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.

For young research scientists who are interested in understanding the dynamics of the human brain, Koch's book provides the ideal introduction. Written in a precise yet easy style, the 21 Chapters of "Biophysics of Computation" begin at the beginning, introducing the reader to elementary electrical properties of membrane patches, linear cable theory, and the properties of passive dendritic trees. These introductory chapters are followed by two on the properties of synapses and the various ways that synapses can interact to perform logic on passive dendritic trees. Then the Hodgkin--Huxley formulation is discussed in detail, and various simplifying models are presented. As a basis for the Hodgkin--Huxley description, our present understanding of ionic channels is reviewed and the importance of calcium currents is emphasized. Further chapters discuss linearization of the H--H equations for small amplitude analysis, a careful examination of ionic diffusion, electrochemical properties of dendritic spines, synaptic plasticity, simple neural models, stochastic neural models, and the properties of bursting cells. Just about every facet of current neural knowledge is touched upon, with appropriate references to a carefully selected bibliography which will help the diligent novice delve deeply into whatever aspect of neural information processing that he or she chooses.
All of the above comprises an extended introduction to Chapters 17 through 19, which in the words of the author: "synthesize the previously learned lessons into a complete account of the events occurring in realistic dendritic trees with all of their attendant nonlinearities. We will see that dendrites can indeed be very powerful, nontraditional computational devices, implementing a number of continuous operations."

Thus "Biophysics of Computation" offers a definitive statement for the direction in which the neural research of the new century should go. Chapter 20, the penultimate, discussed several speculations for non-neural computation in the brain, ranging from molecular computing below the level of a single neuron to the effects of chemical diffusants (nitric oxide, calcium ions, carbon monoxide, etc.) on large numbers of neurons. Although this entire area has been neglected by the neuroscience community, Koch points out that there are no good reasons for doing so.

understanding of ionic channels is reviewed, emphasizing the importance of calcium currents. Further chapters discuss linearization of the H-H equations for small amplitude behavior; present a careful examination of ionic diffusion processes; and describe electrochemical properties of dendritic spines, synaptic plasticity, simple neural models, stochastic neural models and the properties of bursting cells. Just about every facet of currently available neural knowledge is touched upon, with appropriate references to a carefully selected bibliography that will help the diligent novice delve deeply into whatever aspect of neural information processing he or she chooses.

``Thinking about brain style computation requires a certain frame of mind, related to but distinctly different from that of the biophysicist. For instance, how should we think of a chemical synapse? In terms of complicated pre- and post-synaptic elements? Ionic channels? Calcium binding proteins? Or as a non-reciprocal and stochastic switching device that transmits a binary signal rapidly between two neurons and remembers its history of usage? The answer is that we must be concerned with both aspects, with biophysics as well as computation."

This excellent book is evidently a labour of love, stemming from the author's 1982 doctoral thesis on information processing in dendritic trees. As far as I can tell all relevant aspects of neural processing are considered, with what seem to me to be just the proper amounts of emphasis. The writing style is precise and rigorous without being stuffy, and the many references to a fifty-page bibliography will be of enormous value to young researchers starting out in this field.

This is the main book, the "Bible", on single neuron and ion channel computational modeling. Plenty of theory & rigor here! Professor Koch, with CalTech, models single ion channel function, dendrite, dendrite tree function, cable theory, stochastic theories, integrate-fire model, the Poisson model, and discusses how single neurons work together inside the brain. It is worth owning both as a reference book and to use in the laboratory. Dr. Koch has written many other books, but I think this stands out as his best. Methods in Neuronal Modeling 2nd edition is also very good. Koch's writings are complementary, but are not redundant. One can read this book without a problem if you know Calculus.

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. This textbook rectifies the situation by focusing on the repertoire of computational operations available to individual nerve cells. The author suggests how information can be encoded in the voltage across the membrane, in the intracellular calcium concentration, and in the timing of individual spikes, or nerve impulses. Key topics include the linear cable operation, passive dendritic trees and dendritic spines, chemical and electrical synapses and how to treat them from a computational point of view, nonlinear interactions 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 of 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 neuronal code and unconventional models of computation involving molecules, puffs of gas, or neuropeptides. Each chapter ends with a recapitulation of the material presented, and the ultimate chapter presents a summary view of 'neuron-style' computation, ending with a list of strategic questions for research.

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