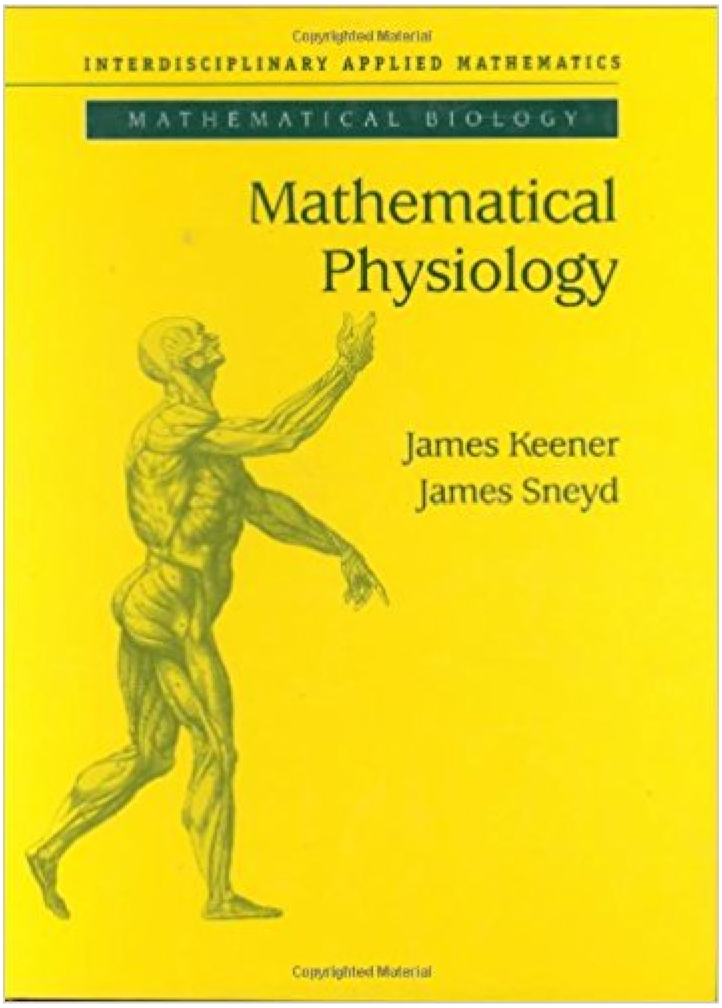
Mathematical Physiology (Interdisciplinary Applied Mathematics)



Synopsis

Mathematical Physiology provides an introduction into physiology using the tools and perspectives of mathematical modeling and analysis. It describes ways in which mathematical theory may be used to give insights into physiological questions and how physiological questions can in turn lead to new mathematical problems.The book is divided in two parts, the first dealing with the fundamental principles of cell physiology, and the second with the physiology of systems. In the first part, after an introduction to basic biochemistry and enzyme reactions, the authors discuss volume control, the membrane potential, ionic flow through channels, excitability, calcium dynamics, and electrical bursting. This first part concludes with spatial aspects such as synaptic transmission, gap junctions, the linear cable equation, nonlinear wave propagation in neurons, and calcium waves. In the second part, the human body is studied piece by piece, beginning with an introduction to electrocardiology, followed by the physiology of the circulatory system, blood muscle, hormones, and kindeys. Finally, the authors examine the digestive system and the visual system, ending with the inner ear. This book will be of interest to researchers, to graduate students and advanced undergraduate students in applied mathematics who wish to learn how to build and analyze mathematical models and become familiar with new areas of applications, as well as to physiologists interested in learning about theoretical approaches to their work. Mathematical Reviews, 2000: "This is neither a physiology book nor a mathematics book, but it is probably the best book ever written on the interdisciplinary field of mathematical physiology, i.e. mathematics applied to modelling physiological phenomena. The book is highly recommended to anybody interested in mathematical or theoretical physiology."

Book Information

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Customer Reviews

From the reviews: "Probably the best book ever written on the subject of mathematical physiology Ã¢â ¬Â| It contains numerous exercises, enough to keep even the most diligent student busy, and a comprehensive list of approximately 600 references Ã¢â ¬Â| highly recommended to anybody interested in mathematical or theoretical physiology." Mathematical Reviews "In addition to being good reading, excellent pedagogy, and appealing science, the exposition is lucid and clear, and there are many good problem sets to choose from Ã¢â ¬Â| Highly recommended." Journal of the Society of Mathematical Biology

This is a very good graduate level text on mathematical physiology. It covers a broad range of topics from cardiac electrophysiology to the cell cycle. The authors have written the closest thing to a mathematical version of Guyton's Human Physiology text that I have seen. The prospective reader of this text should be aware that it assumes a background in PDE ,ODE, and asymptotics, as well as introductory molecular Biology. The structure of DNA, RNA, and the central dogma DNA to RNA to Protein are described in less than 3 pages without diagrams. Terms from Biochemistry are used at times without definition or explanation. Each Chapter concludes with a very nice collection of interesting problems. Supplement the text with the outstanding elementary text by Leah - Edelstein - Keshet , lecture notes by C. Peskin ,the applied math texts by Keener and Cole, Molecular biology texts by Lodish et al or Baltimore et al ,and of course Guyton's Human Physiology for a fascinating introduction to mathematical biology with an emphasis on differential equation models in physiology.

This book is an excellent overview of the major research into the mathematics of physiological processes. The first part of the book covers cellular physiology beginning with a discussion of biochemical reactions in the first chapter. Some of the applications of dynamical systems are nicely illustrated here, especially bifurcation theory. Applications of the diffusion equation follow in the next chapter on cellular homeostasis. The Nernst-Planck electrodiffusion equation is discussed but not derived, and is solved in the constant field approximation. This is complicated somewthat in the next chapter on membrane ion channels, where the potential across the membrane is not assumed to have a constant gradient. There is a discussion of channel blocking drugs in the last section, but unfortunately it is too short. This is an important area of application, with the experimental validation of the mathematical results of upmost importance. The Hodgkin-Huxley and the FitzHugh-Nagumo equations dominate the next chapter on electrical signaling in cells. The phase space analysis of these models is discussed, along with an interesting treatment of the excitability of cardiac cells in the Appendix of the chapter. A very well-written treatment, along with helpful diagrams, of calcium dynamics is given in Chapter 5. The authors show how ignoring the fast variables and transients lead one to a solution of they dynamical problem of the receptor model. Phase space analysis is used extensively in the next chapter on electrical bursting, with emphasis on bursting in pancreatic beta-cells. An interesting discussion on the classification of bursting oscillations is given purely in terms of bifurcation theory. That synaptic transimission is quantal in nature is one of the topics of the next chapter on intercellular communication. This is the first time in the book that probabilistic methods are introduced into the modeling. The authors quote some very old references on the experimental verification of the quantal model, leaving the reader wondering if more modern experiments have been done. In calculating the effective diffusion coefficients, the authors introduce the technique of homogenization, and give a explanation of the rationale behind the technique. The strategy of determining the behavior at a particular scale without solving completely the details at a finer scale is one that has proven to be quite productive, especially in physics. The use of partial differential equations is increased in the next chapter on electrical flow in neurons, with the linear cable equation playing the dominant role. The authors use transform methods to obtain the solutions in the main text and exercises, giving references for the reader not familiar with these techniques. The nonlinear cable equation is the subject of the next chapter, with traveling waves solutions of the bistable equation given the main emphasis. Shooting methods are employed in the solution of this equation, and the authors also treat the more difficult case of the discrete bistable equation. Wave propagation in higher dimensions is the subject of the next chapter, with spiral waves discussed along with a brief discussion of scroll waves. The fascinating subject of cardiac propagation is the subject of Chapter 11. The mathematical techniques are not much more complicated, but mathematicians coming to cardiac biology for the first time will need to pay attention to the details. One of the most interesting subjects of the book is treated in Chapter 13 on cell function regulation. Mathematical models of the G1 and G2 checkpoint processes are given. Part two of the book emphasizes the mathematical modeling of the biological systems, rather than at the cellular level. This part begins with a consideration of how cellular activity can be coordinated to produce a regular heartbeat and how failure can occur. Interestingly, a Schrodinger-like equation appears when linearizing the FitzHugh-Nagumo equations for oscillating cells. And, interestingly, dynamical systems via circle maps appear in the model of the AV modal signal. This is followed by a lengthy and fascinating discussion of the mathematics of the circulatory system. Unfortunately, the discussion on the dangers of high blood pressure is not justified by any mathematical models in the book. It would have been very interesting to see a model developed that would predict the effects of hypertension on the heart, kidneys, etc and one that would be compared with historical and clinical data. The next chapters discuss physiology of the blood, respiration, and muscles. A very interesting discussion of hormone physiology and mammal ovulation is given. The mathematical models of the kidneys and gastrointestinal systems are very detailed and very enlightening for individuals not in these fields. The book ends with chapters on the physiology of sight and hearing. The discussion of the light reflex mechanism is very interesting as the authors use linear stability analysis. The oscillations of the basilar membrane in the inner ear are good reading for the physicist. This book would be of great interest to mathematicians who are entering the field of computational physiology or computational biologists who need an understanding of the modeling required. Very captivating reading........

I wish I had this book when I started in this field. It is so much nicer to learn from such a well written and comprehensive textbook than to try to extract all the information from journal articles. Some background in physiology and, particularly, mathematics (ODE's, algebra, etc.) is required though to make the most out of this book. (Parts of) the book are/is well suited for an advanced course in computational biology.

If you would like to delve into the true complexity of systems biology (physiology), get this book. It's even much better than computational cell biology book by JJ Tyson et al since it's described in depth. But I'd rephrase Tyson's comment: "The regulatory system is so complex that it defies understanding by verbal arguments alone."

I used this book in a graduate school course. I found myself checking out other mathematical physiology books to understand what they were talking about. There's poor explanations, and they skip certain steps that would help the reader get a better understanding of what's going on. Save your money and skip this book.

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