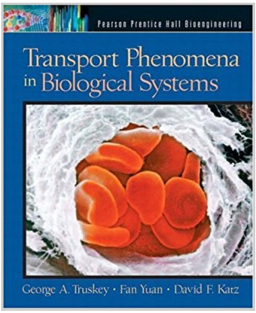

Transport Phenomena in Biological Systems (Pearson Prentice Hall Bioengineering)

By George A. Truskey, Fan Yuan, David F. Katz

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For one-semester, advanced undergraduate/graduate courses in Biotransport Engineering. Presenting engineering fundamentals and biological applications in a unified way, this text provides students with the skills necessary to develop and critically analyze models of biological transport and reaction processes. It covers topics in fluid mechanics, mass transport, and biochemical interactions, with engineering concepts motivated by specific biological problems.

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Editorial Review

From the Back Cover

The efficient transport of molecules is essential for the normal function of cells and organs and the design of devices for medical applications and biotechnology. *Transport Phenomena in Biological Systems* provides an introduction to the integrated study of transport processes and their biological applications.

The book consists of four sections, which cover physiological fluid mechanics, mass transport, biochemical interactions and reactions and the effect of mass transfer, and transport in organs and whole organisms. In order to provide students with a firm understanding of biological transport processes, engineering concepts are provided within the context of specific biological problems. Examples and problems elaborate on the concepts in the text or develop new concepts. The introductory chapter presents a brief overview of transport processes at the cell and tissue level and relevant concepts in cell biology and physiology are presented throughout the text. An appendix provides an overview of relevant mathematical concepts used in the text. The problems at the end of each chapter require either analytical solution or numerical solution using MATLAB®.

This book can be used for both introductory and advanced courses. Advanced topics covered include transport in the kidney, oxygen transport, receptor-mediated processes, cell adhesion, transport of drugs in tumors, and whole body pharmacokinetic models. References are provided for further study.

The transport of energy, mass, and momentum is essential to the function of living systems. Changes in these processes often underlie pathological conditions. Transport phenomena are also central to the operation of instrumentation used to analyze living systems, and to many of the technological interventions used to repair or improve tissues or organs. Transport processes are manifest from the smallest spatial scales of molecular dimensions to the large scales of whole organs and of organisms themselves. They also span the minute time scales of individual chemical events to the lifetimes of living systems. As scientific and technological advancements have shrunk the temporal and spatial scales of observation and understanding of living systems, attention to attendant transport processes at those scales has followed suit.

The objective study of biological transport phenomena began historically in the field of physiology and, indeed, helped define that field. Today, the engineering application of biological transport phenomena contributes to research advances in physiology, immunology, and cell and molecular biology. Thus, transport processes are important considerations in basic research related to molecule, organelle, cell and organ function; the design and operation of devices, such as filtration units for kidney dialysis, high density cell culture and biosensors; and applications including rug and gene delivery, biological signal transduction, and tissue engineering. Clearly, attention to the basic mechanisms of transport processes and, concomitantly, their biological and biomedical contexts, is important to curricula for educating biomedical engineers.

Teaching undergraduate and graduate students in bioengineering about transport phenomena in living systems is challenging. This teaching must integrate the development of fundamental principles of transport processes, the mathematical expression of these principles and the solution of transport equations, along with characterization of composition, structure and function of the living systems to which they are applied. The overwhelming majority of textbooks on transport processes are oriented primarily toward chemical and mechanical engineers, and lack applications and descriptions of biological and biomedical contexts. While many of these texts are excellent, there is a need for a book that integrates biological and engineering concepts in the development of the transport equations and, meanwhile, provides detailed and current applications. It is our goal that this text meets that need.

The materials in this textbook will help to develop both skills and contextual knowledge for engineers, enabling them to establish and critically analyze models of biological transport and reaction processes. We have sought to present engineering fundamentals and biological contexts in a unified way. The book covers topics in fluid mechanics, mass transport, and biochemical interactions and reactions. Inclusion of the latter has great biological and biomedical motivation, since so many relevant processes and technologies involve chemical reactions. Each engineering concept is motivated by specific biological problems. Immediately after the concept is developed, biological and/or biomedical applications are presented. In this way, the student,4an gain an understanding of the specific topic presented, as well as its application to important problems in biology and medicine. Each chapter contains a number of examples and homework problems, that either elaborate upon problems discussed in the text or address new biomedical questions. Problems and examples include analytical as well as numerical solutions. We emphasize analytical solutions because they often provide physical insights that are important for introductory material, even if such insights provide only first-order levels of understanding. More complex problems that require numerical solution are presented and the use of MATLAB in the solution of these problems is discussed. References to current literature are provided for those who are interested in more detailed analyses.

Our target audience consists of advanced undergraduates or graduate students. We assume some exposure to the study of biology, but Chapter 1 summarizes many basic concepts in cell biology and physiology. References to relevant texts in cell biology and physiology are provided. No previous exposure to mass and momentum transport, nor to chemical kinetics is assumed, but understanding of introductory material in chemistry is needed. Although students should be familiar with most of the mathematical concepts that are discussed in the text, we include an Appendix that provides a review of important concepts, and presents material about use of MATLAB in problem solving.

The text contains an introduction and four parts. The introduction describes the motivation for the text and its organization and provides a brief overview of transport processes at the cell and tissue level. The first two parts are based on the analogy in development of principles for momentum and mass transport. Balance relations are presented for momentum (Chapter 2) and mass (Chapter 6), and are applied to some simplified biomedical contexts that demonstrate the effects of geometry and boundary conditions. Next, we develop the conservation and constitutive relations in three dimensions for momentum (Chapter 3) and mass (Chapter 7), and apply them to more complex problems. Subsequent chapters in each part are devoted to specific applications. The third part examines biochemical interactions and effects of mass transport upon these interactions. The fourth part focuses on transport in organs and whole organisms. Applications in all parts range from molecular events within cells (Chapters 11 and 12) to biochemical reactions that affect transport between cells (Chapters 13 to 15). The final chapter of the book synthesizes these concepts by considering several examples of whole-body transport.

This book can be used for both introductory and advanced courses on transport phenomena in biomedical engineering. A one-semester course might include Chapters 1, 2, 3, 6, 7, and 10, and focus on the basic concepts of biological transport phenomena. We present physiological fluid mechanics before diffusion processes to provide a basis for understanding models describing the diffusion coefficient in Section 6.6. It is possible to present the analysis of diffusion (Chapter 6) prior to physiological fluid mechanics, by deferring discussion of Section 6.6 until low Reynolds number flow is presented. Time permitting, one or more of the application chapters could also be covered. An advanced course might use some or all of the chapters on advanced topics (Chapters 4, 5, 8, 9 and 11 through 16).

Contemporary biology, medical science, and biotechnology are replete with important transport problems yet to be solved. Such problems embody interrelationships amongst biological, chemical, and physical processes. By presenting these relationships in the context of biomedical applications, we hope, in this textbook, to provide students and researchers with knowledge and insights needed to address and solve these important problems.

Users Review

From reader reviews:

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