Cardiovascular And Respiratory Systems Modeling

The volumes in this authoritative series present a multidisciplinary approach to modeling and simulation of flows in the cardiovascular and ventilatory systems, especially multiscale modeling and coupled simulations. The cardiovascular and respiratory systems are tightly coupled, as their primary function is to supply oxygen to and remove carbon dioxide from the body's cells. Because physiological conduits have deformable and reactive walls, macroscopic flow behavior and prediction must be coupled to nano- and microscopic events in a corrector scheme of regulated mechanisms. Therefore, investigation of flows of blood and air in physiological conduits requires an understanding of the biology, chemistry, and physics of these systems together with the mathematical tools to describe their functioning. Volumes 1 and 2 are devoted to cell organization and fate, as well as activities that are autoregulated and/or controlled by the cell environment. Volume 1 examined cellular features that allow adaptation to environmental conditions. Volume 2 begins with a survey of the cell types of the nervous and endocrine systems involved in the regulation of the vasculature and respiratory tract and growth factors. It then describes major cell events in the circulatory and ventilatory systems, such as cell growth, proliferation, migration, and death. Circadian cycles that drive rhythmic gene transcription are also covered.
Biodynamic Research Corporation (BRC) completed an SBIR Phase I project to study

the feasibility of developing a model of the Aviator's Breathing System (ABS). The motivation for the project was the desire to develop a model which could simulate the cardiovascular and respiratory responses to altitude and acceleration stress encountered in high performance military aircraft. Software modules were developed and tested for simulation of: (1) the flows and pressures within the breathing gas delivery system; (2) the flows, pressures, and gas distribution within the lung; and (3) the steady-state flows and pressures within the cardiovascular system. Subprograms were also developed to compute altitude barometric pressure relationships as well as passenger cabin pressures in military aircraft. In addition to the software development, BRC reviewed and organized the Government furnished data from a series of manned rapid decompression known as the EONS Experiments. Aircrew breathing system, Rapid decompression, Lung mechanics, Respiratory physiology, mathematical model. This book describes the basic, pathophysiologic, and clinical importance of the reciprocal relationships and interactions between the respiratory and cardiovascular systems, examining mechanical responses caused by lung volume and thoracic pressure. Emphasizes humoral and neurophysical interactions occurring in diseases that lead to cardiorespiratory failure. Covering pulmonary mechanics, respiratory muscle function, exercise physiology, and control of venous return and cardiac output, Respiratory-Circulatory Interactions in Health and Disease focuses on mechanisms of heart failure in respiratory disease details the central interactions in sudden infant death

syndrome considers the control of tissue metabolism, the development of the sympathetic nervous system, mathematical modeling, and image analysis as a tool for investigating cardiocirculatory function examines the effects of muscle reflexes on respiration and circulation analyzes systemic inflammatory response and chronic obstructive lung disease discusses respiratory maneuvers to support failing circulation and ventilation addresses current controversies surrounding the balloon-tipped catheter debates using inhaled nitrous oxide to treat circulatory failure and more! Supplying a rational basis for understanding the ways in which the cardiovascular and respiratory systems interact in normal and abnormal situations, Respiratory-Circulatory Interactions in Health and Disease is a blue-ribbon reference for cardiologists; pulmonologists; physiologists; intensivists; cardiothoracic surgeons; anesthesiologists; asthmatologists; health care practitioners interested in chest, pulmonary, and thoracic medicine; and medical school students in these disciplines.

The volumes in this authoritative series present a multidisciplinary approach to modeling and simulation of flows in the cardiovascular and ventilatory systems, especially multiscale modeling and coupled simulations. Volume 5 is devoted to cells, tissues, and organs of the cardiovascular and ventilatory systems with an emphasis on mechanotransduction-based regulation of flow. The blood vessel wall is a living tissue that quickly reacts to loads applied on it by the flowing blood. In any segment of a blood vessel, the endothelial and smooth muscle cells can sense unusual time variations in

small-magnitude wall shear stress and large-amplitude wall stretch generated by abnormal hemodynamic stresses. These cells respond with a short-time scale (from seconds to hours) to adapt the vessel caliber. Since such adaptive cell activities can be described using mathematical models, a key objective of this volume is to identify the mesoscopic agents and nanoscopic mediators required to derive adequate mathematical models. The resulting biomathematical models and corresponding simulation software can be incorporated into platforms developed in virtual physiology for improved understanding and training.

This presentation describes various aspects of the regulation of tissue oxygenation, including the roles of the circulatory system, respiratory system, and blood, the carrier of oxygen within these components of the cardiorespiratory system. The respiratory system takes oxygen from the atmosphere and transports it by diffusion from the air in the alveoli to the blood flowing through the pulmonary capillaries. The cardiovascular system then moves the oxygenated blood from the heart to the microcirculation of the various organs by convection, where oxygen is released from hemoglobin in the red blood cells and moves to the parenchymal cells of each tissue by diffusion. Oxygen that has diffused into cells is then utilized in the mitochondria to produce adenosine triphosphate (ATP), the energy currency of all cells. The mitochondria are able to produce ATP until the oxygen tension or PO2 on the cell surface falls to a critical level of about 4–5 mm Hg. Thus, in order to meet the energetic needs of cells, it is important

to maintain a continuous supply of oxygen to the mitochondria at or above the critical PO2 . In order to accomplish this desired outcome, the cardiorespiratory system, including the blood, must be capable of regulation to ensure survival of all tissues under a wide range of circumstances. The purpose of this presentation is to provide basic information about the operation and regulation of the cardiovascular and respiratory systems, as well as the properties of the blood and parenchymal cells, so that a fundamental understanding of the regulation of tissue oxygenation is achieved.

This book provides a comprehensive overview of mechanical circulatory support of the failing heart in adults and children. The book uniquely combines engineering knowledge and the clinician's perspective into a single resource, while also providing insights into current and future development of mechanical circulatory support technology, such as ventricular assist devices, the total artificial heart and catheter-based technologies for heart failure. Topics featured in this book include: The history of mechanical circulatory device development. Fundamentals of hemodynamics support. Clinical management of mechanical circulatory devices. Surgical implantation techniques. Current limitations of device therapies in advanced heart failure. Advanced and novel devices in the development pipeline. Opportunities for advancement in the field. Mechanical Support for Heart Failure: Current Solutions and New Technologies is a must-have resource for not only physicians, residents, fellows, and medical students in cardiology and cardiac surgery, but also clinical and basic researchers in biomedical engineering with an

interest in mechanical circulatory support, heart failure, and new technological applications in medicine.

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discarded to allow simple, representative modeling and to manage their inverse problems.

Cardiovascular and Respiratory Bioengineering focuses on computational tools and modeling techniques in cardiovascular and respiratory systems that help develop bioengineered solutions. The book demonstrates how these technologies can be utilized in order to tackle diseases and medical issues. It provides practical guidance on how a bioengineering or medical problem can be modeled, along with which computational models can be used. Topics include computer modeling of Purkinje fibers with different electrical potential applied, modeling of cardiomyopathies caused by sarcomeric gene mutations, altered sarcomere function, perturbations in intracellular ion homeostasis, impaired myocardial energetics at reduced costs, and more. The book also discusses blood flow through deformable blood vessels in human aorta, abdominal aortic aneurysm, carotid artery, coronary artery and plaque formation, along with content on stent deployment modeling and stent design and optimization techniques. Features practical applications of cardiovascular and respiratory technology to counteract diseases Includes detailed steps for the modeling of cardiovascular and respiratory systems Explores a range of different modeling methods, including computational modeling, predictive modeling and multi-scale

modeling Covers biological processes and biomechanics relevant to cardiovascular and respiratory bioengineering

This volume presents one of the clinical foundations of vasculopathies: the biological markers and risk factors associated with cardiovascular disease. A detailed biological and clinical framework is provided as a prerequisite for adequate modeling. Chapter 1 presents cardiovascular risk factors and markers, where the search for new criteria is aimed at improving early detection of chronic diseases. The subsequent chapters focus on hypertension, which involves the kidney among other organs as well as many agents, hyperglycemia and diabetes, hyperlipidemias and obesity, and behavior. The last of these risk factors includes altered circadian rhythm, tobacco and alcohol consumption, physical inactivity, and diet. The volumes in this series present all of the data needed at various length scales for a multidisciplinary approach to modeling and simulation of flows in the cardiovascular and ventilatory systems, especially multiscale modeling and coupled simulations. The cardiovascular and respiratory systems are tightly coupled, as their primary function is to supply oxygen to and remove carbon dioxide from the body's cells. Because physiological conduits have deformable and reactive walls, macroscopic flow behavior and prediction must be coupled to nano- and microscopic events in a corrector scheme of

regulated mechanisms. Therefore, investigation of flows of blood and air in anatomical conduits requires an understanding of the biology, chemistry, and physics of these systems together with the mathematical tools to describe their functioning in quantitative terms.

The availability of well-defined genetic strains and the ability to create transgenic and knockout mice makes mouse models extremely valuable biomedical tools. Their suitability as an experimental system for cardiovascular research depends on the individual investigator's ability to manipulate the mice surgically. Many mouse models require microsurgical techniques, which hitherto could not be performed without practical training. This comprehensive handbook enables scientists to develop these models in their own laboratories. A Handbook of Mouse Models of Cardiovascular Disease is the first book to address pathology in mouse models of heart disease, providing the reader with essential information on technical assays in artificially created models. It includes background information on individual cardiovascular diseases, describes detailed methods and materials used for establishing each mouse model, discusses the problems that may appear in the experiments, and provides examples of applications of the model. A Handbook of Mouse Models of Cardiovascular Disease: Describes mouse models of all important cardiovascular diseases, including

atherosclerosis, atrial fibrillation and thrombosis Features videos of key experimental procedures on the accompanying CD, allowing researchers to learn the techniques by directly watching the whole operational procedure Describes how to establish each experimental model with detailed protocols and tips on dealing with common operational problems Highlights potential applications of each model in areas such as pathogenesis, gene transfer, therapy and pathophysiology This handbook is an invaluable resource for researchers in cardiovascular disease, pathology, physiology, interested in the mechanism of vascular disorders and therapeutic approaches. It is also relevant to clinicians seeking to understand the pathology of cardiovascular disease and the rationale for interventions, and of interest to the pharmaceutical industry and all those involved in drug discovery/development for cardiovascular disease.

Simulation facilities are invaluable for training in medicine and clinical education, biomedical engineering and life sciences. They allow the practice of prevention, containment, treatment, and procedure in a risk-free setting. This book is a practical guide and reference to the latest technology, operations and opportunities presented by clinical simulation. It shows how to develop and make efficient use of resources, and provides hands-on information to those tasked with setting up and delivering simulation facilities for medical, clinical and related

purposes, and the development and delivery of simulation-based education programs A step-by-step manual to developing successful simulation programs Shows how to design, construct, outfit and run simulation facilities for clinical education and research. The Residency Review Committee of the US Accreditation Council on Graduate Medical Education has begun requiring residency programs to have simulation as an integral part of their training programs.

Gathering the proceedings of the 12th CHAOS2019 International Conference, this book highlights recent developments in nonlinear, dynamical and complex systems. The conference was intended to provide an essential forum for Scientists and Engineers to exchange ideas, methods, and techniques in the field of Nonlinear Dynamics, Chaos, Fractals and their applications in General Science and the Engineering Sciences. The respective chapters address key methods, empirical data and computer techniques, as well as major theoretical advances in the applied nonlinear field. Beyond showcasing the state of the art, the book will help academic and industrial researchers alike apply chaotic theory in their studies.

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This book (vol. 1) presents the proceedings of the IUPESM World Congress on Biomedical Engineering and Medical Physics, a triennially organized joint meeting of medical physicists, biomedical engineers and adjoining health care professionals. Besides the purely scientific and technological topics, the 2018 Congress will also focus on other aspects of professional involvement in health care, such as education and training, accreditation and certification, health

technology assessment and patient safety. The IUPESM meeting is an important forum for medical physicists and biomedical engineers in medicine and healthcare learn and share knowledge, and discuss the latest research outcomes and technological advancements as well as new ideas in both medical physics and biomedical engineering field.

This volume synthesizes theoretical and practical aspects of both the mathematical and life science viewpoints needed for modeling of the cardiovascular-respiratory system specifically and physiological systems generally. Theoretical points include model design, model complexity and validation in the light of available data, as well as control theory approaches to feedback delay and Kalman filter applications to parameter identification. State of the art approaches using parameter sensitivity are discussed for enhancing model identifiability through joint analysis of model structure and data. Practical examples illustrate model development at various levels of complexity based on given physiological information. The sensitivity-based approaches for examining model identifiability are illustrated by means of specific modeling examples. The themes presented address the current problem of patient-specific model adaptation in the clinical setting, where data is typically limited.

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length scales for a multidisciplinary approach to modeling and simulation of flows in the cardiovascular and ventilatory systems, especially multiscale modeling and coupled simulations. The cardiovascular and respiratory systems are tightly coupled, as their primary function is to supply oxygen to, and remove carbon dioxide from, the body's cells. Because physiological conduits have deformable and reactive walls, macroscopic flow behavior and prediction must be coupled to nano- and microscopic events in a corrector scheme of regulated mechanism. Therefore, investigation of flows of blood and air in physiological conduits requires an understanding of the biology, chemistry, and physics of these systems, together with the mathematical tools to describe their functioning in quantitative terms. The present volume focuses on macroscopic aspects of the cardiovascular and respiratory systems in normal conditions, i.e., anatomy and physiology, as well as the acquisition and processing of medical images and physiological signals.

This Monograph provides an update on cardiovascular disease complications and treatment implications for respiratory diseases, based on current scientific evidence and considered from an epidemiological, pathophysiological and clinical point of view. This book also discusses the future challenges when studying the complex relationship between these two groups of disorders.

This unique book offers a comprehensive and integrated introduction to the five fundamental elements of life and society: energy, information, feedback, adaptation, and self-organization. It is divided into two parts. Part I is concerned with energy (definition, history, energy types, energy sources, environmental impact); thermodynamics (laws, entropy definitions, energy, branches of thermodynamics, entropy interpretations, arrow of time); information (communication and transmission, modulation–demodulation, coding–decoding, information theory, information technology, information science, information systems); feedback control (history, classical methodologies, modern methodologies); adaptation (definition, mechanisms, measurement, complex adaptive systems, complexity, emergence); and self-organization (definitions/opinions, self-organized criticality, cybernetics, self-organization in complex adaptive systems, examples in nature). In turn, Part II studies the roles, impacts, and applications of the five above-mentioned elements in life and society, namely energy (biochemical energy pathways, energy flows through food chains, evolution of energy resources, energy and economy); information (information in biology, biocomputation, information technology in office automation, power generation/distribution, manufacturing, business, transportation), feedback (temperature, water, sugar and hydrogen ion

regulation, autocatalysis, biological modeling, control of hard/technological and soft/managerial systems), adaptation and self-organization (ecosystems, climate change, stock market, knowledge management, man-made self-organized controllers, traffic lights control).

The aim of this book is to spread and make easier the use of comprehensive modelling for research, educational and clinical applications. Flexible and modular numerical, physical and hybrid models developed to assess patho-physiology of cardiovascular and respiratory systems are the subject of the book. The models discussed in the book are effective and easy to use tools to simulate circulatory and respiratory systems, their interactions and their mechanical support. The models can be applied to analyse data, predict the trend of selected variables not routinely measured and to identify critical variables to be monitored. Spreading of comprehensive modelling can offer to physicians and engineers powerful tools to analyse complex phenomena and interactions involving circulatory and respiratory systems along with their mechanical assistance. The complexity of the circulatory and respiratory systems makes their analysis very difficult or sometimes impossible in clinical environment.

Cardiovascular, respiratory, and related conditions cause more than 40 percent of all deaths globally, and their substantial burden is rising, particularly in low-

and middle-income countries (LMICs). Their burden extends well beyond health effects to include significant economic and societal consequences. Most of these conditions are related, share risk factors, and have common control measures at the clinical, population, and policy levels. Lives can be extended and improved when these diseases are prevented, detected, and managed. This volume summarizes current knowledge and presents evidence-based interventions that are effective, cost-effective, and scalable in LMICs.

The parameter identification problem attempts to find parameter values that cause the solution of a predictive model to match data. In this work, parameters in cardiovascular and respiratory models are identified. This workÃ¢â'¬â"¢s main contribution is in its application of gradient based optimization techniques and insight into methods to identify parameters that can be estimated given subject specific data. The models presented in this paper are lumped compartment models of the cardiovascular and respiratory systems. Lumped compartment models treat the cardiovascular and respiratory systems as collections of interconnected compartments transporting blood and exchanging oxygen and carbon dioxide. Using these compartments, a system of ordinary differential equations (ODE) is generated that incorporates several physiological parameters representing vascular resistances, compliances, and tissue metabolic rates. The

solution to this ODE system is used to predict cerebral blood flow, systemic arterial blood pressure, and expired carbon dioxide partial pressures, which are then compared to subject data. Minimizing the two-norm difference between between the result of the predictive model and the experimental data is a non-linear least squares problem. Although the least squares problem is overdetermined, the data do not contain enough information to determine all model parameters. A combination of sensitivity analysis, expert knowledge, and subset selection techniques reduce the number of model parameters estimated. Mathematical and numerical modelling of the human cardiovascular system has attracted remarkable research interest due to its intrinsic mathematical difficulty and the increasing impact of cardiovascular diseases worldwide. This book addresses the two principal components of the cardiovascular system: arterial circulation and heart function. It systematically describes all aspects of the problem, stating the basic physical principles, analysing the associated mathematical models that comprise PDE and ODE systems, reviewing sound and efficient numerical methods for their approximation, and simulating both benchmark problems and clinically inspired problems. Mathematical modelling itself imposes tremendous challenges, due to the amazing complexity of the cardiovascular system and the need for computational methods that are stable,

reliable and efficient. The final part is devoted to control and inverse problems, including parameter estimation, uncertainty quantification and the development of reduced-order models that are important when solving problems with high complexity, which would otherwise be out of reach.

This book introduces mathematicians to real applications from physiology. Using mathematics to analyze physiological systems, the authors discuss models reflecting current research in cardiovascular and pulmonary physiology. In particular, they present models describing blood flow in the heart and the cardiovascular system, as well as the transport of oxygen and carbon dioxide through the respiratory system and a model for baroreceptor regulation. This is the only book available that analyzes up-to-date models of the physiological system at several levels of detail; both simple 'real-time' models that can be directly used in larger systems, and more detailed 'reference' models that show the underlying physiological mechanisms and provide parameters for and validation of simpler models. The book also covers two-dimensional modeling of the fluid dynamics in the heart and its ability to pump, and includes a discussion of modeling wave-propagation throughout the systemic arteries.

Cardiovascular and Respiratory Systems: Modeling, Analysis, and Control uses a principle-based modeling approach and analysis of feedback control regulation to

elucidate the physiological relationships. Models are arranged around specific questions or conditions, such as exercise or sleep transition, and are generally based on physiological mechanisms rather than on formal descriptions of input-output behavior. The authors ask open questions relevant to medical and clinical applications and clarify underlying themes of physiological control organization. Current problems, key issues, developing trends, and unresolved questions are highlighted. Researchers and graduate students in mathematical biology and biomedical engineering will find this book useful. It will also appeal to researchers in the physiological and life sciences who are interested in mathematical modeling.

With cardiovascular diseases being one of the main causes of death in the world, quantitative modeling, assessment and monitoring of the cardiovascular control system plays a critical role in bringing important breakthroughs to cardiovascular care. Quantification of cardiovascular physiology and its control dynamics from physiological recordings and by use of mathematical models and algorithms has been proved to be of important value in understanding the causes of cardiovascular diseases and assisting the prognostic or diagnostic process. Nowadays, development of new recording technologies (e.g., electrophysiology, imaging, ultrasound, etc) has enabled us to improve and expand acquisition of a wide spectrum of physiological measures

related to cardiovascular control. An emerging challenge is to process and interpret such increasing amount of information by using state-of-the-art approaches in systems modeling, estimation and control, and signal processing, which would lead to further insightful scientific findings. In particular, multi-disciplinary engineering-empowered approaches of studying cardiovascular systems would greatly deepen our understanding of cardiovascular functions (e.g., heart rate variability, baroreflex sensitivity) and autonomic control, as it would also improve the knowledge about heart pathology, cardiovascular rehabilitation and therapy. Meanwhile, developing cardiovascular biomedical devices or heart-machine interface for either clinical monitoring or rehabilitation purpose is of greater and greater interest for both scientific advancement and potential medical benefits. This Research Topic will bring together established experts whose areas of research cover a wide range of studies and applications. Contributions include but are not limited to state-of-the-art modeling methodologies, algorithmic development in signal processing and estimation, as well as applications in cardiovascular rehabilitation, and clinical monitoring. The Research Topic will consider both invited reviews and original research.

This book describes the state of the art of the mathematical theory and numerical analysis of imaging. Some of the applications covered in the book include computerized tomography, magnetic resonance imaging, emission tomography, electron microscopy, ultrasound transmission tomography, industrial tomography, seismic tomography,

impedance tomography, and NIR imaging.

This volume presents the proceedings of the CLAIB 2016, held in Bucaramanga, Santander, Colombia, 26, 27 & 28 October 2016. The proceedings, presented by the Regional Council of Biomedical Engineering for Latin America (CORAL), offer research findings, experiences and activities between institutions and universities to develop Bioengineering, Biomedical Engineering and related sciences. The conferences of the American Congress of Biomedical Engineering are sponsored by the International Federation for Medical and Biological Engineering (IFMBE), Society for Engineering in Biology and Medicine (EMBS) and the Pan American Health Organization (PAHO), among other organizations and international agencies to bring together scientists, academics and biomedical engineers in Latin America and other continents in an environment conducive to exchange and professional growth.

This book provides an overview of current activities in the fascinating area between computer science and sports, presenting the state of the art in utilising the latest developments in computer science to support sports coaches and athletes. It covers a broad range of topics reflecting the diversity of this interdisciplinary field, including concepts in informatics like expert systems, modelling, simulation, machine learning, robotics, and sensor integration. Further, it describes applications of computer science in sports, such as alpine skiing, badminton, football, rowing, and table tennis, as well as interesting applications areas of sport like dementia, physiology, training, and space

flights. The appeals to informaticians interested in the application field of sports as well as for sports scientists and practitioners looking for advanced methods in their particular sport.

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devices, which incorporate a stage of numerical tests in addition to experimental procedures.

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