Preface

The investigation of the role of mechanical and mechanochemical interactions in cellular processes and tissue development is a rapidly growing research field in life sciences and in biomedical engineering. Quantitative understanding of this important area in the study of biological systems requires the development of adequate mathematical models for the simulation of the evolution of these systems in space and time. This calls for a multidisciplinary approach since expertise in various fields is necessary.

Due to the necessity to describe the processes at different spatial and temporal scales, numerous approaches are used in the modeling of biomaterials. Methods of statistical physics may be employed at the subcellular or cellular level (e.g., in models of biomembranes or cellular interactions). When moving to the level of organs, continuum mechanics may be a more suitable approach. A combination of continuum and discrete approaches may be used, for instance, in the heart, which is typically modeled as a viscoelastic material with active stress generated by chemical interactions of actin and myosin molecules.

The objective of the present book, entitled **Modeling Biomaterials** and consisting of six independent chapters, is at least twofold. On the one hand, each chapter can be viewed as an introduction to a given field, where the reader is exposed to various approaches to modeling different materials, such as living tissues. On the other hand, each chapter has been written by active researchers with the goal of connecting the basic foundations of their field with very recent advances and open questions. The result is six chapters covering basic physical, biological, and physiological concepts as well as further research perspectives from multiple points of view.

It is our belief that the multidisciplinary nature of each chapter will stimulate the interaction of researchers from various domains of science (including applied mathematics, biophysics, mathematical biology, computational physiology, pharmacology, and medicine), for whom the book will provide a helpful starting point, particularly at the start of their research career in these interdisciplinary fields. Thanks to the wide range of approaches that arise in models of living tissues, the

book may also serve as a useful reference for experienced researchers working in these fields.

While the first four chapters are universal in their approach and are not explicitly related to a specific organ, Chaps. 5 and 6 survey the recent advances in models of the cardiovascular system, including state-of-the-art clinical applications in cardiovascular medicine.

The individual chapters (lecture notes) stem from the lecture courses presented by the speakers of the international doctoral school "Modeling of Biomaterials," which took place in Kácov (Czech Republic), February 10–16, 2020. In several cases, the speakers prepared their contributions with co-workers. The book consists of the following chapters (the names of the speakers who were, at the same time, the corresponding authors for a particular chapter, are typeset in boldface):

1. **Oded Farago**: *A Beginner's Short Guide to Membrane Biophysics*
2. Georgios Misailidis, Jaroslav Ferenc, and **Charisios D. Tsiairis**: *Self-organization of Tissues Through Biochemical and Mechanical Signals*
3. Michele Righi and **Valentina Balbi**: *Foundations of Viscoelasticity and Application to Soft Tissue Mechanics*
4. **Václav Klika**: *Modelling of Biomaterials as an Application of the Theory of Mixtures*
5. Renee Miller, David Marlevi, Will Zhang, Marc Hirschvogel, Myrianthi Hadjicharalambous, Adela Capilnasiu, Maximilian Balmus, Sandra Hager, Javiera Jilberto, Mia Bonini, Anna Wittgenstein, Yunus Ahmed, and **David Nordsletten**: *Modeling Biomechanics in the Healthy and Diseased Heart*
6. **Radomír Chabiniok**, Katerina Škardová, Radek Galabov, Pavel Eichler, Maria Gusseva, Jan Janoušek, Radek Fučík, Jaroslav Tintěra, Tomáš Oberhuber, and Tarique Hussain: *Translational Cardiovascular Modeling: Tetralogy of Fallot and Modeling of Diseases*

The delivered lectures and the chapters of this book focus on mechanical and mechanochemical interactions in cellular processes and tissue development. The topics ranged from molecular dynamics simulations of lipid membranes to phenomenological continuum mechanics of tissue growth.

We wish to express our gratitude to all corresponding authors and their co-workers for their effort in preparing their chapters in a way that is accessible to nonspecialists, yet useful to the experts in the field.

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