Preface

The cells of our bodies represent a very large class of systems whose structural components often are both complex and soft. A system may be *complex* in the sense that it may comprise several components having quite different mechanical characteristics, with the result that the behavior of the system as a whole reflects an interplay between the characteristics of the components in isolation. The mechanical components themselves tend to be *soft*: for example, the compression resistance of a protein network may be more than an order of magnitude lower than that of the air we breathe. Cells have fluid interiors and often exist in a fluid environment, with the result that the motion of the cell and its components is strongly damped and very unlike ideal projectile motion as described in introductory physics courses. While some of the physics relevant to such soft biomaterials has been established for more than a century, there are other aspects, for example the thermal undulations of fluid and polymerized sheets, that have been investigated only in the past few decades.

The general strategy of this text is first to identify common structural features of the cell, then to investigate these mechanical components in isolation, and lastly to assemble the components into simple cells. The initial two chapters introduce metaphors for the cell, describe its architecture and develop some concepts needed for describing the properties of soft materials. The remaining chapters are grouped into three sections. Parts I and II are devoted to biopolymers and membranes, respectively, treating each system in isolation. Part III combines these soft systems into complete, albeit mechanically simple, cells; this section of the text covers the cell cycle, various aspects of cell dynamics, and some molecular-level biophysics important for understanding cell function.

Each chapter begins with an experimental view of the phenomena to be addressed, and a statement of the principal concepts to be developed. Those chapters with a fair amount of mathematical formalism are written such that a reader may skip to the last section of the chapter, without going through traditional physics-style derivations, to see the results applied in a biological context. The approach is to keep the mathematical detail manageable without losing rigor. Care has been taken to choose topics that can be approached within a common theoretical framework; this has forced the omission of some phenomena where a disproportionate effort would be required to assemble the related theoretical machinery. Some of the longer proofs and other support material can be found through the Cambridge University Press website for this book.

Reflecting the multidisciplinary nature of biophysics, four appendices provide quick reviews of introductory material related to the text. For the physicist, Appendices A and B focus on animal cell types and the molecular composition of the cell's mechanical components, respectively. For the biologist, Appendices C and D introduce some core results from statistical mechanics and elasticity theory. The end-of-chapter problems are grouped according to (i) applications to biological systems, and (ii) formal extensions and supplementary derivations. The text is suitable for a one-semester course delivered to senior undergraduate and beginning graduate students with an interest in biophysics. Some formal results from the problem sets may provide additional lecture material for a more mathematical course aimed at graduate students in physics.

Compared to the first edition of this text, the second edition is 50% longer and the number of homework problems per chapter has been doubled. All of the original chapters have been reviewed, updated and reworked as needed. Four new chapters have been added, expanding the treatment of fluids and dynamical processes such as cell growth and division, as well as placing more emphasis on single-molecule aspects of cell mechanics. The mathematical description of soft, fluctuating systems is now part of the text and presented in a dedicated introductory chapter.

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The staff at Cambridge Press, particularly Rufus Neal, Simon Capelin and John Fowler, have helped immensely in bringing focus to the book and placing its content in the larger context. However, the lingering errors, omissions and obfuscations are my responsibility, and I am always appreciative of suggestions for ways to improve the quality of the text.

Dave Boal