Preface

Life is a motion! This is true at all levels of living systems, from cells to organisms, but in most cases we still do not fully understand the fundamental origin of such dynamics. In this book we would like to explore and discuss mechanisms of cellular functioning associated with several specific enzymatic molecules that are called motor proteins.

Motor proteins, also known as molecular motors, play important roles in living systems by supporting cellular transport and force generation via transformation of chemical energy into mechanical work. Examples include gene replication and transcription, protein synthesis and degradation, muscle contraction, signal transduction, transport of proteins, vesicles and organelles, cell motility, and segregation of chromosomes during cell division. Significant research activities have been undertaken in order to understand molecular mechanisms of motor protein motility and functioning. Furthermore, these efforts are also stimulated by the technological and medical needs of developing new drugs, nanoscale devices, and materials that would lead to desirable biochemical and biophysical properties of biological molecular motors. Because of the strong interdisciplinary nature of motor proteins, this research area has attracted a large and diverse set of scientists from various fields ranging from cell biology, biochemistry and biophysics to physics, materials science, and bioengineering. This field also strongly requires a unified molecular picture for analyzing motor proteins.

The central idea associated with motor protein functioning is the concept of transformation of one type of energy (chemical) into another one (mechanical). This is further complicated by the fact that molecular motors operate in solutions at isothermal but highly non-equilibrium conditions; their dynamics is coupled with multiple biochemical transitions. In addition, motor proteins move along cytoskeleton protein filaments or nucleic acid molecules in a crowded and confined cellular environment, involving a variety of chemical, mechanical, electrostatic, and hydrodynamic interactions. Taking all these factors into account in explaining the complex behavior of motor proteins is not an easy task! To develop a unified microscopic approach for analyzing complex processes in molecular motors, an application of fundamental concepts from physics and chemistry is required.

With this goal in mind, in this book we present a summary of established results, theoretical methods, and experimental observations related to biological molecular motors. In our approach we utilize fundamental physical-

chemical ideas and methods in order to develop a systematic theoretical framework for understanding motor protein dynamics. The main ideas and concepts are presented using simple arguments that avoid heavy mathematical derivations in favor of more intuitive physical understanding. Although the book assumes some rudimentary knowledge of cell biology, calculus, and basic ideas from chemistry and physics, for most presented results, explanations and derivations are given. It is important to note that the book is not a comprehensive review of all known experimental and theoretical results on motor proteins. We aim here to connect major experimental facts on molecular motors to principal theoretical concepts that are consistent with the fundamental laws of chemistry and physics. It is our intention to produce a book on motor proteins that will be accessible to undergraduate, graduate students, and other researchers from a wide range of scientific fields including biology, biochemistry, biophysics, chemistry, physics, materials science, and engineering.