Preface

The cell interior is another world that we are only beginning to explore. Although there are a number of approaches for examining the inner workings of the cell, the reductionist approach of building up complexity appeals to many with physical science and engineering backgrounds. Such experiments are appealing because the complexity of the cellular organism can be built up systematically adding in one new element at a time and dialing up the concentrations of each component in a systematic way. The hope is that such bottom-up approaches will garner new quantitative insights at many levels. At the lowest level, we seek to elucidate single molecule activities to be able to have quantitative numbers for analytical models and simulations. As new components are added to one another, their activities can combine synergistically to create novel emergent behaviors. Since biology is inherently out of equilibrium, there is energy being injected that can enhance such synergies making even simple-seeming systems appear complex and inherently interesting. Such emergence of complex behavior from interactions of simple components is likely to have been critical for the origins of life. Further, reductionist scientists are seeking to determine the minimal diversity of components to create cell-like structures and activities. Especially in eukaryotic systems, the number of components controlling cell function appears unnecessarily large and the methods for cellular control appear baroque. By determining the minimal variety of proteins of each function to perform a specific task, scientists are beginning to create a molecular toolkit of activities. This avenue of research also has implications for a new area of cellular bioengineering based on cell-like nanodevices.

Another interesting issue of the cell is the variety and diversity of systems one can choose to work on. Of course, reductionists are seeking to give fundamental and universal insight to these processes, so they typically focus on aspects of the cell that appear fundamental. As such, many of the authors contributing to this volume have chosen to focus on the cytoskeleton and membrane systems to ultimately combine the two into cell-like patterns and organizations.

We have grouped together contributed chapters that have similar focuses, starting with wholly in vitro reconstitutions of cytoskeleton. These contributions include methods for combining different motors and cytoskeletal components in defined ways to produce more complex behaviors, as well as methods to combine cytoskeletal assemblies with fabricated devices such as chambers or pillar arrays.

Next we move to the membrane systems reconstituted in vitro. Contributions in this area include chapters on reconstituting membrane fission and fusion, as well as reconstituting important biological processes that normally take place on membrane surfaces, such as cell division and polarity.

Finally, we finish with systems that attempt to recreate cells as encapsulated systems of chemicals that can act together as a machine to perform functions. These chapters describe methods for encapsulating protein machines within vesicles or droplets. The chapters of this book thus span a range of spatial scales from single protein molecules to vesicle- and cell-sized structures capable of complex behaviors.

These represented systems certainly are not complete, and many more scientists are applying quantitative, systematic strategies to understand DNA, the nucleus, organelles, and countless other systems. It is our hope that this volume will be instructive to ultimately enable researchers to bridge the gaps between different experimental systems. Until all the reduced systems are combined together, we will not truly be able to reconstruct a working cell.

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