1 Introduction

Over the past several decades, researchers around the world have exploited a light-responsive protein called "bacteriorhodopsin" (bR) to create a variety of thin organic films that can function as photocells, photoelectric biotransducers, and light-driven proton pumps. In nature, the bR molecules are found in the cellular membranes of the salt-marsh archaebacteria *Halobacterium salinarium* and are used to generate the potential difference necessary for synthesizing adenosine triphosphate (ATP) from adenosine diphosphate (ADP). Under oxygen-limited conditions, the *Halobacterium* cell grows planar purple membrane (PM) patches in the form of a hexagonal 2-D crystalline lattice of bR trimers. When exposed to visible light beams, each bR molecule acts as a simple proton pump, which transports hydrogen ions from the cytoplasmic to the extracellular side through a transmembrane ion channel that connects both sides of the membrane. The crystalline structure is the basis of the bR material's chemical and thermal stability.

From an engineering perspective, the proton transfer mechanisms of bR PMs have been used to develop a number of different optoelectronic devices. For example, bR-coated silica microcavities and microspheres have been used to perform all-optical switching in the near-infrared spectrum. Additionally, the bR PMs have been deposited and immobilized on optically transparent indium tin oxide (ITO) electrodes to construct bioelectronic photodetector arrays that respond to light intensity, movement of light patterns, and color (i.e., spectral sensitivity). The proton transfer mechanisms of bR PMs have also been used to fabricate photoelectric biotransducers for activating ionic gel actuators in microfluidic chips. In these devices, the flow of ions from the photon-activated bR changes the pH value of the ionic solution that surrounds the hydrogel microactuator or microvalve. Once the pH of the gel's solution is shifted to the phase transition point pKa, the chargeable pendant groups of the polymeric network undergo a measureable geometric transition. However, the fabrication of efficient thin photoelectric layers and their directional proton pumps requires the molecular recognition of the extracellular side of the bR proton pumps and effective immobilization of the PM monolayer on the functionalized substrate.

This Spotlight briefly summarizes the molecular behavior of bR, introduces thin-film fabrication techniques with an emphasis on molecular self-assembly, and describes its application to all-optical switches, bioelectronic photosensing, and light-driven microactuation. The primary goal of this book is to advance the understanding of photosensitive bioelectronics technology and provide an inspiration for the next generation of scientists and engineers to develop innovative solutions far beyond anything that we can imagine today. The opportunities for product innovation, by applying the basic principles of light-responsive bR films, are illustrated by several novel systems.