A. Introduction

Rhodopsin, the visual pigment of the rod cell, governs early steps of the visual process by its concerted interactions with the G-protein transducin, rhodopsin kinase, and arrestin. The precise interaction with transducin is crucial for single photon detection by rod cells. The rate of transducin turnover catalyzed by a single rhodopsin molecule in the dark is lower than $10^{-6}$ per second and increases to $10^3$ after light activation. The visual receptor/G-protein system, designed for low noise-signal amplification, may operate near to the upper physical limit set to biological signal transduction. On the other hand, rhodopsin and transducin are fundamentally similar to other receptors and G-proteins, and understanding this specialized system may help to understand such systems in general. Studies of the visual system are supported by specific physical properties, as the activation by light, the colored receptor intermediates, and the variable membrane binding of the G-protein. Part of this chapter is dedicated to techniques of physical biochemistry and how to employ them in the study of rhodopsin/G-protein interaction. Some of the insights may also apply to the related systems. Other recent reviews deal with rhodopsin and transducin from different perspectives, including the role of rod outer segment structure (LIEBMAN et al. 1987), molecular details of the interaction (HAMM 1991), structure and function of rhodopsin (HARGRAVE and McDOWELL 1992; HARGRAVE et al. 1993) and of seven-helix receptors in general (HARGRAVE 1991), molecular biology (KHOHANA 1992) and spectroscopy (SIEBERT 1992) of rhodopsin, and the role of transducin in the visual process (HOFMANN and KAHLEHT 1992; LAMB and PUGH 1992).

B. Interactions of Rhodopsin in the Visual Cascade

Rhodopsin is embedded in disc-shaped intracellular membrane vesicles, which form long stacks in the outer segments of rod cells. A pair of discs is schematically shown in Fig. 1A. G-protein (transducin, G$_t$) and effector (a cyclic GMP phosphodiesterase, PDE) are peripheral membrane proteins. Activation of the PDE effector via receptor and G$_t$ leads to the hydrolysis of
Fig. 1A–C. Rhodopsin and the visual cascade. A Components of the visual cascade. Rhodopsin (R), G-protein (G), and cGMP phosphodiesterase (PDE) are located in and on the disc membrane. Bovine disc membranes are ca. 1.5 μm in diameter and form long stacks in the outer segment. The very fluid disc membrane contains R at a density of 25 000 μm⁻²; the relative abundance of R, G and PDE is 100:10:1. See text and LIEBMAN et al. (1987) for details. B Rhodopsin and its chromophore, 11-cis retinal. The schematic picture shows the disposition of the seven transmembrane helical stretches, the cytoplasmic loops and the negative charges along the third helix. The intradiscal loops are omitted. C The visual cascade. The scheme shows the light-induced formation of the active photoproduct, MII, its deactivation by phosphorylation via a rhodopsin kinase (RK) and subsequent binding of arrestin (A), and the G-protein cycle. See text for details.