Abstract Type: Review

Biophysics of light-sensing proteins and their applications in Optogenetics

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Rhodopsins are photoreceptive proteins and key tools in optogenetics. Although rhodopsin was originally named as a red-colored pigment for vision, the modern meaning of rhodopsin encompasses photoactive proteins containing a retinal chromophore in animals and microbes. Animal and microbial rhodopsins respectively possess 11-*cis* and all-*trans* retinal, respectively. As cofactors bound with their animal and microbial rhodopsin (seven transmembrane α-helices) environments, 11-*cis* and all-*trans* retinal undergo photoisomerization into all-*trans* and 13-*cis* retinal forms as part of their functional cycle. While animal rhodopsins are G protein coupled receptors, the function of microbial rhodopsins is highly divergent. Many of the microbial rhodopsins are able to transport ions in a passive or an active manner. These light-gated channels or light-driven pumps represent the main tools for respectively effecting neural excitation and silencing in the emerging field of optogenetics.

A wide variety of light-sensing proteins that are found in plants and microorganisms and that provide natural resources for engineering optogenetic tools are briefly reviewed. We include microbial rhodopsins, which absorb blue/green light; phytochromes, which absorb red/far-red light; UV-A/blue-absorbing flavoproteins (cryptochromes, LOV-domain proteins, BLUF-domain proteins); and the recently discovered UV-B sensor UVR8. Among them, the significance of channelrhodopsins, photoactivated adenylyl cyclases, biophysics of rhodopsins and their relationship to optogenetics are reviewed.

Keywords: Optogenetics, Photoreceptor, Light sensing protein