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Cyanobacterial Rhodopsins: Light-Driven Proton Pump GR (Gloeorhodopsin) and ASR (*Anabaena* Sensory Rhodopsin) for Regulating Gene Expression of Photosynthetic Pigments

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Multi-functional microbial rhodopsins function as light-driven ion transporter and sensory receptor in microbes. The rhodopsin from the fresh-water cyanobacterium *Anabaena* sp. PCC7120 is a sensory rhodopsin (ASR) with a relatively slow photocycle, and its function appears to be involved modulation of a soluble cytoplasmic transducer (ASRT). On the other hand, rhodopsin from *Gloeobacter violaceus* is light-driven proton pump coexisted with photosynthetic machinery. It is known that rhodopsin accommodates both all-*trans* and 13-*cis* retinal in the ground state, which can be inter-converted between them by light illumination. The genes were functionally expressed in *Escherichia coli* and bound all-*trans* retinal to form a pigment (GR=544 nm and ASR=545nm, pH 7). GR showed a light-driven proton pumping activity similar to proteorhodopsin. We tried to show the interaction of ASR with ASRT (14 kDa soluble transducer) which is involved in physiological photo-regulation. First, we tested that ASR interacts with transducer and ASRT was also bound to promoter region of *cpc* (phycocyanin), *pec* (phycoerythrocyanin), *kai* ABC and *asr* operon. Second, in order to confirm the ASR transducer regulates the expression level of the proteins related chromatic adaptation, we compared the mRNA expression level of the genes which are involved in production of phycobilisomes. It is suggested that the ASR and ASRT protein regulate the expression of the gene involved in chromatic adaptation at the transcription level. Therefore, ASR functions as a photoreceptor that monitors the quality of light and transmitted the information into cytoplasmic region through ASR transducer.