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Light-induced transcriptional responses of proteorhodopsin-containing marine bacteria

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Proteorhodopsin (PR) is a photoprotein that functions as a light-driven proton pump in diverse marine Bacteria and Archaea. Recent studies have suggested that PR may enhance both growth rate and yield in some flavobacteria when grown under nutrient limiting conditions in the light. The direct involvement of PR, and the metabolic details enabling light-stimulated growth, however, remain uncertain.

Here, we surveyed transcriptional and growth responses of a PR-containing marine flavobacterium during carbon-limited growth in the light and the dark. As previously reported (1), Dokdonia strain MED134 exhibited light-enhanced growth rates and cell yields under low carbon growth conditions. Inhibition of retinal biosynthesis abolished the light-stimulated growth response, supporting a direct role for retinal-bound PR in light enhanced growth. Among protein-coding transcripts, both PR and retinal biosynthetic enzymes showed significant upregulation in the light. Other light-associated proteins, including bacterial cryptochrome and DNA photolyase, were also expressed at significantly higher levels in the light. Membrane transporters for Na+/phosphate and Na+/alanine symporters, and the Na+-translocating NADH-quinone oxidoreductase (NQR) linked electron transport chain, were also significantly upregulated in the light (2).

Culture experiments using a specific inhibitor of Na+-translocating NQR indicated that sodium pumping via NQR is a critical metabolic process in the light-stimulated growth of MED134. In total, the results suggested the importance of both the PR-enabled, light-driven proton gradient, as well as the generation of a Na+ ion gradient, as essential components for light-enhanced growth in these flavobacteria (2).

1. Gomez-Consarnau et al., Nature 445: 210-213, 2007.
2. Kimura et al., The ISME Journal 5: 1641-1651, 2011.

Keywords: marine bacteria, proteorhodopsin, proton pump, photoheterotrophy, transcriptomics