OA1.9 - Impact of the stringent response for controlling photosynthesis and chloroplast function in photosynthetic microorganisms

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Organisms have to respond to environmental changes for their survival. To do this, each species has evolved multitude cellular regulatory systems. In the case of bacteria, one of the most important regulatory systems is the so-called stringent response. This response is achieved by the controlled synthesis and degradation of the unusual nucleotide, guanosine 5'-triphosphate 3'-diphosphate (pppGpp) and guanosine 5'-diphosphate 3'-diphosphate (ppGpp), which function as second messengers. When *Escherichia coli* grown under nutrient rich conditions were transferred to nutrient-limited conditions, cellular levels of (p)ppGpp in the cells were rapidly and significantly increased. (p)ppGpp controls many aspects of the cellular processes such as transcription and translation as well as several enzyme activities, and the response allows the bacteria to fine tune the transcription of a large number of genes in response to alteration of nutrient conditions. In *E. coli*, pppGpp/ppGpp were synthesized by the two enzymes RelA and SpoT; pppGpp is converted to ppGpp by specific phosphatases GppA and Ppx.

We previously characterized the stringent response in the photosynthetic bacterium *Rhodobacter capsulatus,* and showed that the stringent response has important roles not only for adaptation to nutrient deficiency, but also controlling photosynthesis gene expression[1]. In addition, we have characterized the (p)ppGpp synthases and hydrolyases conserved in plants[2], which are called RSHs (RelA/SpoT homologs). The plant RSH proteins, characterized to date, are all targeted to chloroplasts, suggesting that they are important for controlling chloroplast function.

To better understand the (p)ppGpp-dependent stringent response in phototrophs, we performed comprehensive database search and phylogenetic analysis of RSHs and GppA/Ppx enzymes in microalgae[3]. The green alga *Chlamydomonas reinhardtii* has three distinct RSHs, and one of the RSHs localizes in chloroplasts and its gene expression is up-regulated at the late-log growth phase. The knockdown mutant of the gene showed impairment of photoautotrophic growth, suggesting that the stringent response is crucial for algal cells. Based on other findings, significance of the stringest response for controlling chloroplast functions as well as for establishing conditions that mimics nutrient deficiancy for increasing algal biomass will be discussed.

References

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