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An unorthodox bacteriophytochrome controlling an important bacterial second messenger, c-di-GMP

Mark Gomelsky

University of Wyoming, Laramie, WY, United States

Conventional bacteriophytochromes sense red/far-red light using biliverdin and function as photoactivated protein histidine kinases. I will present photochemical and enzymatic characterization of the unconventional bacteriophytochrome, BphG1 from *Rhodobacter sphaeroides*. BphG1 contains GGDEF and EAL output domains involved, respectively, in synthesis (diguanylate cyclase) and degradation (phosphodiesterase) of c-di-GMP, a bacterial second messenger controlling motile-to-sessile lifestyle transitions. BphG1 covalently binds biliverdin IXα and interconverts between red- (dark) and far-red (light-activated) forms. Similar to GGDEF-EAL proteins studied to date it has only one, c-di-GMP phosphodiesterase, activity. However, unexpectedly for a photochromic protein, this activity is essentially light-independent. The protein can undergo proteolysis that releases its C-terminal EAL domain. The N-terminal fragment containing the photoactivation module and GGDEF turned out to possess diguanylate cyclase activity, which is strongly activated by light. An 'EAL-lock' model of the regulation of the opposite activities of BphG1 will be presented. The identification of a non-kinase photoactivated enzymatic activity confirms the notion that photosensory modules of bacteriophytochromes can control various outputs, which opens up possibilities for their utilization for engineering red-light regulated proteins.