Modern agriculture relies on crops that have been carefully tailored for environments by selective breeding. Phytochromes are attractive targets for crop improvement efforts aimed to enhance seed germination, seedling establishment, plant architecture and flowering time. The overall goal of my lab's research is to understand the structural basis of both photosensory and regulatory functions of phytochromes from cyanobacteria to plants. Such basic knowledge will be leveraged for development of new strategies to alter the light responsiveness of agriculturally significant plant species. For example, our discovery of dominant photochemically uncoupled phytochrome alleles holds significant promise for crop improvement. Such plant-derived reagents may overcome environmental concerns while addressing the pressing need for increased food production on a finite amount of arable land needed to nourish the growing world population.

Current Research Support

_National Institutes of Health_ (RO1 GM068552), J. Clark Lagarias, Principal Investigator, "Molecular Mechanisms of Phytochrome Signaling". This project focuses on gaining fundamental knowledge about the phytochrome family of protein light sensors. Phytochromes utilize linear tetapyrroles (bilins) as chromophores to sense light quality, quantity and duration. Photochemical light sensing triggers conformational changes that modulate the behavior of living systems via target molecules that regulate downstream transcriptional cascades. These investigations
address the hypothesis that the fundamental mechanism of light sensing has remained conserved throughout billions of years of evolution since endosymbiotic capture of a cyanobacterium by a phagotrophic eukaryotic host. There are three specific aims focused on conservation of photoconversion and protein-chromophore interactions in plant and cyanobacterial phytochromes, the evolutionary genesis of plant phytochrome, and phytochrome photoconversion and signaling activity in land plants. By examining phytochromes from evolutionarily distant species ranging from cyanobacteria to plants, we seek to elucidate the basis of light sensing and the intramolecular structural changes that are used to control gene expression. For these studies, we leverage computational analyses to guide experimental design, protein biochemistry and molecular biology to express and purify photoreceptors, enzymology and spectroscopy to understand light-induced changes in photoreceptor structure, and in vivo assessment of nuclear translocation and function in the model land plant Arabidopsis thaliana.

**Department of Energy** (DE-FG02-09ER16117), Principal Investigator, J. Clark Lagarias; Co-PIs James Ames, R. David Britt, Delmar S. Larsen and John C. Meeks, “SISGR: Photoreceptor Regulation and Optimization of Energy Harvesting In Nostoc punctiforme”

These studies seek to characterize and exploit the biliprotein photosensors of the phytochrome superfamily found in the model cyanobacterium Nostoc punctiforme. Our ongoing studies will examine how representative members of this family function and elucidate the biological processes that they regulate. This project combines approaches ranging from ultrafast characterization of photochemical processes through biochemical analysis of signal transduction and genetic examination of this cyanobacterium. A longer-term goal of these studies is to use these light-sensing proteins as synthetic tools for regulating the expression of arbitrary target genes in response to the color or intensity of ambient light. Such tools can be used to tailor cyanobacteria for more efficient, sustainable, and carbon-neutral biological capture of sunlight and conversion and storage of that light as chemical energy.

**National Science Foundation** (IOS-1239577) Principal Investigator, J. Clark Lagarias “EAGER: Leveraging phytochromes for dominant developmental control of plants”

Modern agriculture relies on crops that have been carefully tailored for environments by selective breeding. Phytochromes are an attractive target for conventional breeding programs, because they are key regulators of plant growth and development in response to light and shade. Such programs aim to improve germination, seedling establishment, leaf development, and flowering time. We recently discovered a dominant, constitutively activated allele of phytochrome B whose expression impacts all of these processes. The overall goals of this project are to leverage these alleles for selective regulation of light responses in plants and to develop a plant-derived, antibiotic-free genetic selection marker in selected crop plant species. This project not only will provide new insight into phytochrome function cut may have potential broad impact for the improvement of crop plants.
Selected peer-reviewed publications (since 2010)


