
Light is the most important energy source for photosynthetic organisms. To optimize light absorption, these organisms have evolved sophisticated photoreceptors to regulate growth and development. The red/far-red light absorbing phytochrome is a major photoreceptor to mediate photomorphological controls in plants. Although light sensing and gene regulation by phytochromes has been extensively studied in higher plants, information on phytochrome functions in nonvascular plants is relatively less. In *Physcomitrella patens*, a model system for nonvascular plants, the research team led by Dr. Shih-Long Tu recently found an alternative mechanism for light sensing and gene regulation of phytochromes. This finding provides an explanation on how green plants adapt the light-rich environment during land colonization.

For light sensing and signaling, phytochromes need the open-chain tetrapyrrole molecules as chromophore to fully function. Biosynthesis of tetrapyrrrole chromophores requires members of ferredoxin-dependent bilin reductases (FDBRs). It was shown for a long time that phytochromobilin (PΦB) synthase (HY2) is the only FDBR in plants producing the chromophore for phytochromes. However in nonvascular plants, Dr. Tu’s lab identified a second FDBR producing the phycourobilin (PUB), a tetrapyrrrole pigment usually found in cyanobacteria and red algae. Thus, they named the newly-found enzyme PUB synthase (PUBS). PUBS can only be found in green algae, mosses, and lycophytes, implicating the loss of this gene during evolution of seed plants. In *Physcomitrella patens*, targeted disruption of HY2 and PUBS genes produced severe phytochrome-deficient phenotypes. This result indicates both FDBRs function redundantly in photomorphogenic responses of nonvascular plants. Using mRNA sequencing for transcriptome profiling, they further demonstrate that moss phytochromes efficiently re-program gene expression for phototrophic growth in the light. This approach allows, for the first time, to have a global view of phytochrome-mediated gene regulation in nonvascular plants.
Distinct Phytochrome Actions in Non-vascular Plants Revealed by Targeted Inactivation of Phytobilin Biosynthesis


The red/far-red light photoreceptor phytochrome mediates photomorphological responses in plants. For light sensing and signaling, phytochromes need to associate with chromophores. Biosynthesis of chromophores requires ferredoxin-dependent bilin reductases (FDBRs). It was shown that LONG HYPOCOTYL 2 (HY2) is the only FDBR in flowering plants. However in the moss Physcomitrella patens, we identified a second FDBR producing an alternative chromophore for phytochromes. We named the newly-found enzyme phycourobilin synthase (PUBS). PUBS can only be found in green algae, mosses, and lycophytes, suggesting this gene is important for green plants to adapt the light-rich environment during land colonization. We further identified phytochrome-regulated genes in Physcomitrella. Results reveal that moss phytochromes efficiently re-program gene expression for phototrophic growth in the light. This approach allows, for the first time, to have a global view of phytochrome-mediated gene regulation in nonvascular plants.