Use of optogenetics to mimic a cell-signaling event

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Signaling processes are at the heart of cellular responses to environmental cues. Thanks to a precisely controlled exchange of signals between nucleic acids, proteins, organelles and cells, many mechanisms of living cells are perfectly regulated, like the metabolic machinery, cell growth, differentiation, death and the survival in a dynamic environment.
In this study, we designed a synthetic system that mimics a full cell-signaling event in mammalian cells, starting with (i) the reception of an external signal, then (ii) the recruitment of proteins at the plasma membrane in order to allow transduction of the signal and finally (iii) the nuclear translocation of transcription factors. This system can be simplified by using phytochromes, which are plant photoreceptors that naturally convert the information contained in light into biological signal. In a previous work, we designed a light-induced transport of a genetically engineered phytochrome B (phyB) that is imported into the nucleus upon red-light activation, and exported out of the nucleus after far-red-light activation. Together with this module, we added complexity by adding a membrane anchor to its dedicated NLS-harboring Phytochrome Interaction Factor 3 (PIF3), which could be cleaved by a split-Tobacco Etch Virus (TEV) protease under small-molecule control. Finally, this artificial system mimics a cell-signaling event that can be controlled in each step of the process, by controlling genetically engineered proteins at high spatial and temporal resolution.