**Developing a detailed map of gene expression and implementing tools to reprogram population-level dynamics utilizing fungal optogenetics.**

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The filamentous fungus *Neurospora crassa* perceives and responds to blue light through a transcriptional heterodimer named White Collar Complex (WCC), which contains a LOV (Light Oxygen Voltage) domain capable of detecting blue wavelengths, which promotes a conformational change that leads to dimerization, resulting in strong transcriptional activation, in a light-intensity dependent manner.

We have adopted optogenetic approaches to further delve into Neurospora’s light-responses. In doing so, we were able to genetically program 2D-images in this organism. Thus, we can project a photograph on top of a Neurospora carrying a luciferase reporter under the control of a light responsive promoter and obtain back a bioluminescent pattern mimicking the original image: a *live canvas* in which images are genetically processed and reconstituted with real-time dynamics. This technology provides a great way to assess transcriptional profiles obtaining (literally!), a picture of gene expression, and also to explore the properties of genetic circuits, circadian systems, and transcriptional (eidetic) memory.

In addition, through the development of Neurospora-based optogenetic switches we have successfully implemented blue-light responding transcriptional systems in *Saccharomyces cerevisiae*. Thus, in yeast, we can now efficiently induce gene expression over 3000-fold, over a vast range of transcriptional degrees. By switching on/off the lights, we can control biotechnological relevant phenotypes such as flocculation. Importantly, we have also created complex population dynamics by combining exocrine and optogenetic systems, further proving how light serves as a potent orthogonal signal to reprogram simple and collective traits, and to study population dynamics and the emergence and properties of cheaters.