Using proteins as molecular light bulbs

For a very long time, humans have taken advantage of the microorganism *Saccharomyces cerevisiae,* a unicellular species of yeast, to produce food and beverages such as bread and beer. Thanks to scientific advances, we are now able to tailor microorganisms, such as the yeast we have used for thousands of years, to work as micro-scale factories for production of, for example, pharmaceuticals or biofuels. In this project I have worked on finding suitable parts for a tool which hopefully can help researchers figure out what processes are taking place in the microorganisms and how to manipulate them to create the best possible micro-scale factories. I found a small collection of molecular light bulbs which make yeast cells glow in different colors.

Many people likely associate proteins with something that we eat or a something that builds up the muscles in our bodies. While both these things are true, there is a massive range of different proteins which, thanks to differences in structure, have a variety of functions in all living beings. In this project I assessed proteins with specific structures which allow them to emit fluorescence, or simply put, shine in different colors. Most of the proteins that I assessed shone very brightly, and this opens possibilities to essentially use them as molecular light bulbs.

No light bulb starts to glow by itself, there's always a person who switches it on. Likewise, the molecular light bulbs also need to be switched on to be able to glow. This is done by connecting them to molecular light switches, much like electric wires are connected between the lamps in your living room and the switches on your walls. The molecular light switches can be turned on by specific molecules which attach to the switches. So, the idea is that when a specific process occurs inside a microorganism, this will trigger the activation of a specific light switch, resulting in a brightly glowing molecular light bulb and thereby also a brightly glowing microorganism. Thus, researchers can figure out what process is going on in the microorganism based on which colored light bulb has been turned on. In addition, researchers can figure out how intensely a process is being carried out based on how strongly the microorganism is glowing.

The process of tailoring a microorganism to produce a compound of human interest is very complex – essentially it comes down to "hacking" the intricate metabolic system and re-programming it. Hacking is done by performing many precise edits to the DNA of the microorganism. It is crucial that the best edits are made to generate an optimal micro-scale factory out of the microorganism. Currently, the various ways for researchers to assess and screen for the best edits are complex and require a lot of time. This is where the molecular light switches and light bulbs can come in handy.

In this project, I found several proteins which have potential to be used as molecular light bulbs in the yeast species called *S. cerevisiae.* It is hoped that these proteins will be of use to facilitate the process of engineering *S. cerevisiae* to produce both fine chemicals (e.g. pharmaceuticals) and bulk chemicals (e.g. biofuel). One may wonder why researchers would go through such a long and complicated process to produce these commodities when there are already chemical processes in place for such production. The reason is that taking advantage of microorganisms has the potential to be a much more sustainable production method, for example by reducing reliance on fossil resources, since the microorganisms can be fed with renewable resources.