Electrifying Redox Enzymes for Next-Generation Biotransformations: Harnessing Light and Nanotechnology

Supervisory team:
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Project description:
Electrifying Redox Enzymes for Biotransformations: A Light-Driven Approach
This project explores a groundbreaking method to control redox enzyme activity using light, aiming to revolutionize biotransformations for applications in fields like catalysis, biofuel production, and environmental remediation. Redox enzymes are crucial for electron transfer reactions, and their precise control opens up new possibilities for efficient, high-precision chemical processes.

At the core of this research is the integration of **plasmonic nanoparticles**—nanostructures with unique optical properties. When exposed to light, these nanoparticles generate localized electric fields that can be harnessed to regulate enzyme functionality. By immobilizing redox enzymes onto plasmonic nanoparticles, the project seeks to manipulate the electron transfer process with high precision. Fine-tuning factors such as nanoparticle size, surface chemistry, and the distance between the enzyme and the nanoparticle will enable optimal electron flow, enhancing enzymatic activity.

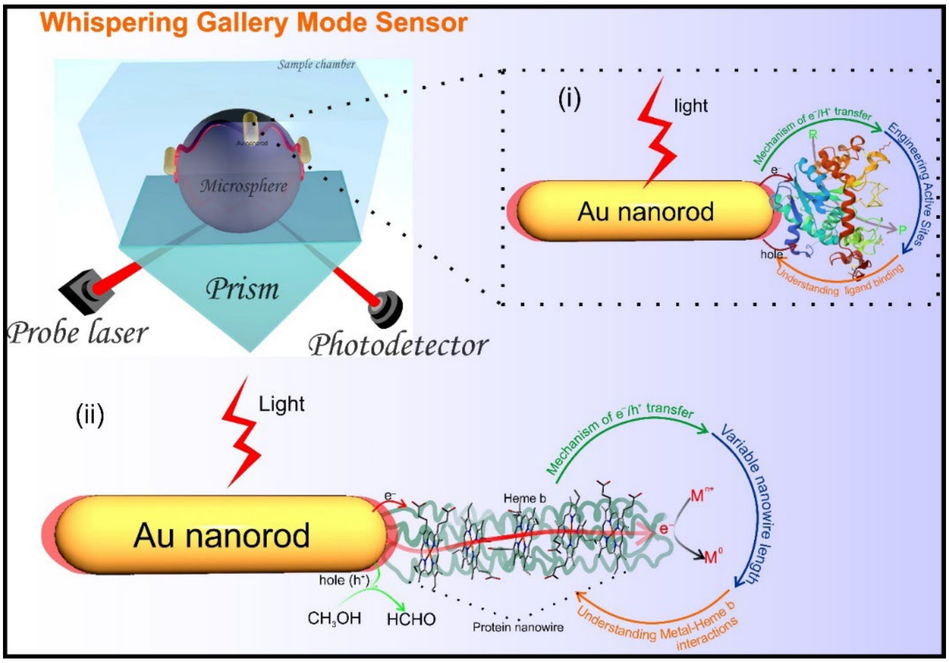

Figure 1Electrifying Redox Enzymes for Next-Generation Biotransformations: Harnessing Light and Nanotechnology

A key focus is to understand the interaction between the enzyme and nanoparticle surfaces and how light excitation alters these dynamics. This project will leverage **optoplasmonic sensors**—ultra-sensitive devices capable of detecting single molecules. Developed in Prof Vollmer's lab, these sensors will allow for detailed exploration of enzyme activity, ligand binding, and electron transfer processes.

In addition, the project will use **synthetic biology** to engineer redox enzymes that respond to light. This creates a novel **optogenetic interface**, where light can precisely control enzyme behavior, enabling complex chemical conversions with high accuracy. The ability to regulate enzyme activity with light also enables synchronized, multi-step biochemical reactions, improving the efficiency of biosynthetic pathways.

A particularly exciting avenue involves **long-range electron transfer** using engineered protein nanowires. These nanowires, containing heme groups, can harvest electrons generated at the surface of gold nanoparticles and transport them across distances of up to 14 nanometers. This approach opens the door to creating **nano-catalysts** capable of driving highly efficient chemical reactions.

In summary, this project aims to unlock the full potential of light-controlled redox enzymes for biotransformations by combining cutting-edge nanotechnology, sensor development, and synthetic biology. The outcomes could significantly impact clean energy, green chemistry, and biotechnology.

Our aim as the SWBio DTP is to support students from a range of backgrounds and circumstances. Where needed, we will work with you to take into consideration reasonable project adaptations (for example to support caring responsibilities, disabilities, other significant personal circumstances) as well as flexible working and part-time study requests, to enable greater access to a PhD. All our supervisors support us with this aim, so please feel comfortable in discussing further with the listed PhD project supervisor to see what is feasible.