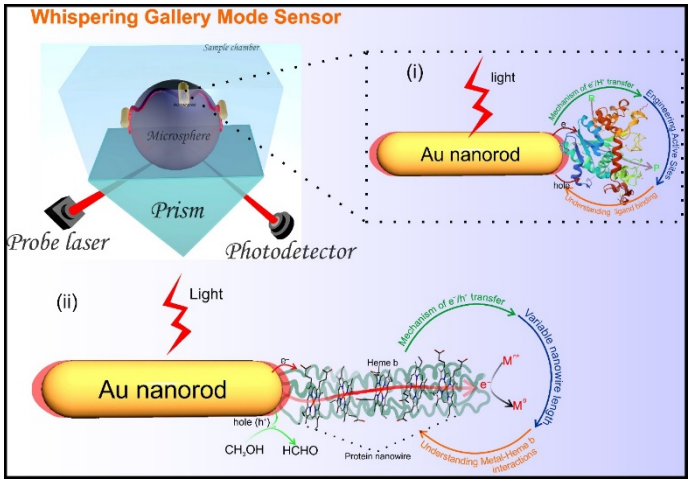
Exploring the Potential of Light-Driven Biocatalysis - Electrifying the engineered redox enzymes for biotransformations

Supervisory team:
Main supervisor: Prof Frank Vollmer (University of Exeter)
Second supervisor: Prof Ross Anderson (University of Bristol)
Prof Nic Harmer (University of Exeter)

Collaborators: Dr Srikanth Pedireddy (University of Exeter)

Host institution: University of Exeter (Streatham)



Project description:
Scientists in the field of bioscience are studying how electrons transfer between inorganic-organic enzyme interfaces. They are focusing on the interaction between plasmonic particles, protein nanowires and enzyme electron sinks, to facilitate biotransformation based on their redox chemistry (see figure). The transfer of electrons between these entities can be controlled by light, making it possible to optimize biotransformations at the nanoscale.

Your mission is to delve into the intriguing prospect of affixing redox enzymes onto plasmonic nanoparticles, transforming them into responsive catalysts that can be controlled by light. This research project, funded by SWBio DTP studentship, combines innovative single-molecule sensor technology from Prof Vollmer's lab in Exeter, with protein engineering techniques from Prof Anderson's lab in Bristol and Dr Harmer's lab in Exeter. The goal is to investigate electron/hole transfer, ligand/substrate binding, and light harvesting mechanisms in unprecedented detail. The project's synthetic biology aspect allows for control of enzyme activity on plasmonic single-molecule sensors, which initiates the redox reaction with electrons generated on the sensor through light. This creates a new optogenetic interface where proteins engineered to carry out biological functions controlled by light can manipulate redox reactions of enzymes with high precision, enabling conversion of complex molecules.

The project also involves studying the electron transfer mechanism at variable lengths (2-14 nm) utilizing engineered protein nanowires containing Heme b centres. The research aims to harvest electrons generated at the surface of gold nanorods, at the other end of the protein nanowire, to generate metal nano island catalysts (as shown in Figure 1(ii)) that can drive chemical conversions.

Research Goals: Understanding Enzyme-Nanoparticle Interaction: Our primary goal is to shed light on the intricate relationship between enzymes and nanoparticle surfaces when exposed to light.

Electron/Hole Transfer for Enzymatic Redox Transformations: We aspire to elucidate the electron/hole transfer mechanisms that underlie enzymatic redox reactions.

Long-Range Electron Harvesting: We aim to develop a mechanism for efficiently harvesting electrons generated on nanoparticle surfaces, a crucial step toward driving chemical conversions.

This ambitious project not only promises groundbreaking insights into the world of nanoscale biocatalysis but also paves the way for the development of novel optogenetic interfaces, where synthetic biology empowers enzymes to perform biological functions under the control of light.

Join us in this scientific journey as we unlock new frontiers in precision biocatalysis and advance our understanding of the fascinating interplay between light, enzymes, and nanotechnology.

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.