Building integrated bionanohybrid circuits by design: understanding and applying single protein molecule function.

Supervisory team:
Main supervisor: Dr Dafydd Jones (Cardiff University)
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Host institution: Cardiff University

Project description:
Merging ideas and principles from biology with nanoscience has proved pivotal in improving our fundamental understanding of nature and the generation of new technologies that improve our everyday lives. Your project aims to embrace this principle to look at how individual protein molecules function and how these emergent properties can be used in new nanoscale applications.

It has recently emerged that proteins are inherently electrically conductive and biomolecular events can modulate conductance. Your project will utilise this exciting new concept to develop and apply a nano-scale approach to probe single protein molecule function through construction of solution-compatible integrated bioelectronic devices. Building on recent work by the supervisory team you will generate user-defined single protein molecule junctions between carbon nanotubes (CNTs) and measure conductance across the protein junction. Dynamic changes in the bond network that underlie protein structure and function will alter conductance characteristics and output signal in real time over an extended timescale. This novel conductance-based approach will allow fundamental investigations of protein function with single molecule resolution and will in the longer term facilitate applications in biomolecular electronics and biosensing. Crucially, you will be able to control the orientation and thus conductance pathway through the protein by incorporating new chemical coupling handles at designed residue positions that will define the protein bridging configuration. This will allow unprecedented access to protein function at the single molecule level and provide new insights in the underlying processes by which proteins conduct.

You will focus on two protein systems. The first is fluorescent proteins which will allow you to optically gate conductance across the junction so generating light-gated bio-transistors. The second relates to one of the grand challenges in healthcare: antimicrobial resistance (AMR). Beta-lactamase (BL) enzymes that break down the most important class of antibiotics, the Beta-lactams (e.g. ampicillin) will act as the molecular bridges and electrical signals will be mapped onto events in the catalytic process.

The project team has a unique combination of expertise, with a strong background in engineering proteins for nanoscale applications, quantitative single molecule imaging and nanoscale fabrication and measurement of bionanohybrids. The nature of the project means you be trained in a wide variety of techniques including protein design, genetic manipulation, non-natural amino acids incorporation, protein chemistry, single molecule imaging, nano-scale fabrication and quantitative data analysis.