Building new nano-biosensors for healthcare: Linking biology to nanoscience through synthetic biology and computational modelling

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

Project description:
One of the grand challenges in nanotechnology is to exploit the molecular properties of proteins within the world of nanoscience to construct next generation miniaturised biosensors for use in environmental detection systems, clinical monitoring and even in the fight against antimicrobial resistance. The protein will communicate with the nanomaterial so that events in one elicit a change in the other (e.g. changes in electrical signal), which will form the basis of a biosensing nanodevice. The main problem is how best to design such biosensors for maximum performance, especially with regards to how a recognition protein is attached to the nanomaterial. This PhD project aims to take an important step to addressing this grand challenge by engineering proteins to interact in a very precise and defined way with one of the most important class of nanomaterials, nano-carbon, focusing on carbon nanotubes (CNTs).

Rapid detection of infectious diseases is one area of great importance, especially in healthcare diagnostics, environmental monitoring and food quality assurance. Detection of specific disease biomarkers relies on the use of binding proteins that have a high affinity and specificity for desired targets and to attach them to nanocarbon as a highly sensitive detection material. The project will use nanobodies, smaller forms of antibodies, attached to CNTs as the basic biosensing device. Nanobodies are the perfect choice for use in biosensors as they retain the specificity of their larger cousins but are more stable, are amenable to protein engineering and can easily be produced recombinantly in bacteria. The initial focus of your project will be biomarkers associated with norovirus, a disease which has significant health and economic impacts.

To build the biosensor, computational modelling will be used to predict the best nanobody attachment site. Then, synthetic biology will be used to introduce new biology not found in nature (reprogrammed genetic code) to define attachment of the nanobody to the CNT. The nanoscale device will then be constructed and tested to measure response to disease associated biomarkers in terms of changes in electrical conductance.

This truly interdisciplinary will build on your interests in biochemistry/biotechnology and synthetic biology but include elements of chemistry and physics, including single molecule analysis.

Techniques: Computational analysis and protein design, nanobody engineering (cloning and mutagenesis), synthetic biology (reprogrammed genetic code systems), protein chemistry (purification and analysis), biophysical analysis (fluorescence and surface plasmon resonance), single molecule imaging (Atomic force microscopy), biosensor construction and electrical measurements.

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.