

Development of a Quantum-Dot-Based Closed-Loop Biosensing and Selective Photochemical Platform for Immune Modulation in Multiple Sclerosis

Project ID: 3605

Supervisory team

Lead supervisors: Prof Thom Sharp (University of Bristol) & Dr Ibidapo Williams (University of the West of England; UWE)

Other supervisors: Prof Paul Verkade (University of Bristol), Prof Ruth Morse (University of the West of England; UWE), Prof Janice Kiely (University of the West of England) & Prof Richard Luxton (University of the West of England)

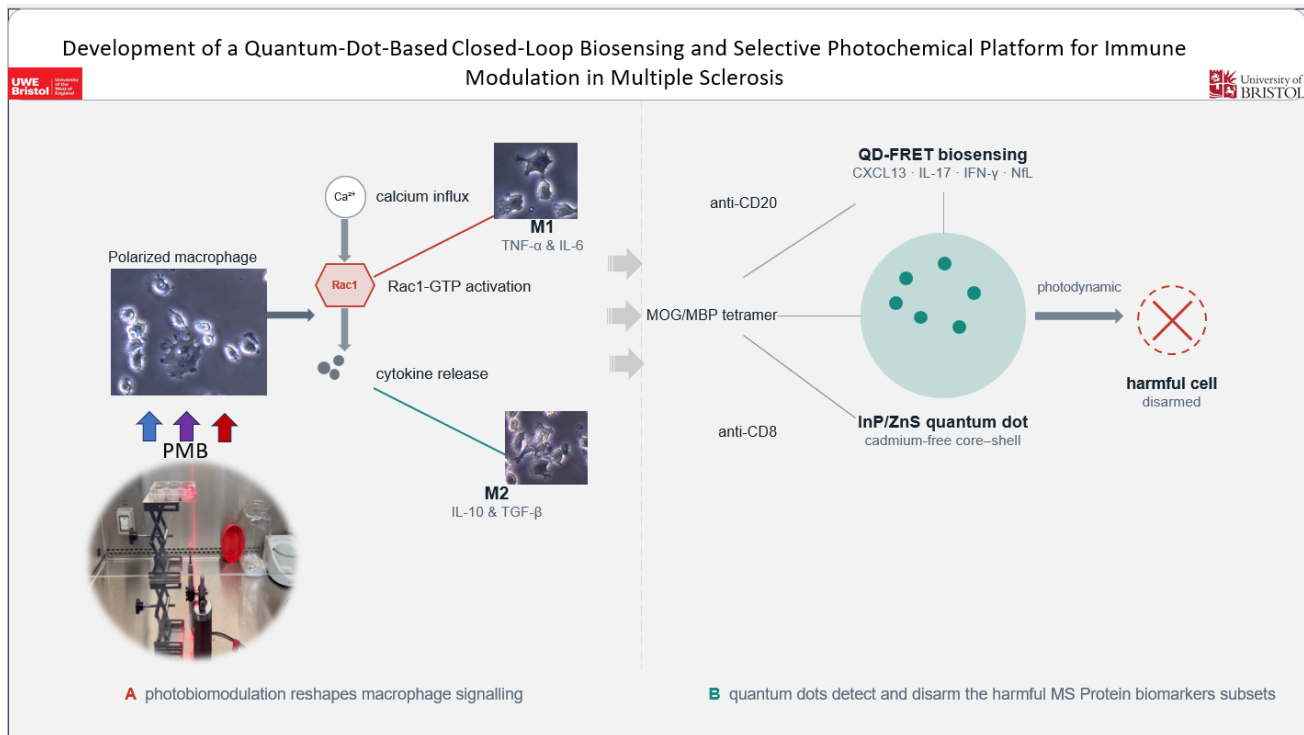
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Registered institution: University of the West of England (UWE) & University of Bristol*

Host institutions: University of the West of England (UWE)/University of Bristol

Project description: Multiple sclerosis (MS) is a chronic autoimmune disease in which dysregulated immune signalling drives inflammatory attacks on the central nervous system, with over 3M people living with MS globally and over 150K people in the UK. Pathogenic CD4⁺ and CD8⁺ T cells, B cells and macrophages cross the blood–brain barrier (BBB), initiate demyelination, and cause irreversible neuroaxonal damage. Current therapies rely on broad immunosuppression and fixed dosing schedules rather than precise modulation of the signalling pathways that initiate and sustain autoimmune activity. This project aims to develop light-controlled immunomodulation as both a mechanistic discovery tool and a translational therapeutic strategy for MS. The project will examine how photobiomodulation (PBM) - red and near-infrared light delivered at defined wavelengths modulates macrophage activation, calcium flux, Rac1 GTPase signalling, cytokine production and inflammatory phenotype. Macrophages are central drivers of tissue destruction in chronic inflammation: M1 macrophages promote pro-inflammatory cytokine release, whereas M2 macrophages promote healing. The project will test the hypothesis that PBM reshapes this balance by altering calcium-dependent Rac1 signalling and will assess whether Rac1 inhibition represents a complementary strategy for restoring immune homeostasis. Building on these insights, the project will extend light-controlled immunomodulation into a nanophotonic engineering approach. Using cadmium-free InP/ZnS quantum dots, the student will develop dual-function photonic tools capable of (i) biosensing inflammatory biomarkers (CXCL13, IL-17, IFN- γ , neurofilament light chain) via quantum-dot mediated resonance energy transfer (QD-FRET), and (ii) selective photodynamic suppression of harmful immune subsets using ligand-targeted quantum-dot photosensitiser conjugates (anti-CD20, MOG/MBP tetramers, anti-CD8). This creates a translational pathway from PBM-driven signalling discovery to a closed-loop “detect-and-disarm” photonic platform for an MS disease. The student will employ macrophage and lymphocyte models stimulated with bacterial and immunological cytokines. At UWE Bristol, they will conduct immunological assays (cytokine profiling, Rac1 activity, RT-PCR, western blotting), quantum-dot biosensor-fabrication and photonic dosimetry. At the University of Bristol, in Prof Thom Sharp and Professor Verkade’s group Sharp, they will use advanced imaging (calcium-imaging, fluorescence probes for gene activation, live-cell microscopy, CLEM, 3D-electron-tomography and cryo-EM to map signalling-dynamics) and visualise how PBM and quantum-dot phototherapy alter cellular structure and function. Later stages will integrate biosensing and phototherapy modules into microfluidic blood-brain barrier models and primary immune-cell systems. By linking intracellular signalling with engineered photonic biosensor modulation, the PhD will deliver fundamental insight into light-responsive immune regulation and support the development of innovative, non-invasive therapeutic strategies for an MS disease. Continued on the next page.....

Please note: This project is in collaboration with the University of Bristol and the University of the West of England (UWE) and subject to a **joint degree award. Successful applicants will be registered at both these institutions, and graduates will be awarded a joint degree from these two institutions upon successful completion of the PhD programme.*



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.