Leveraging the Mechanics of Double Network Hydrogels as Soft, Strong Materials

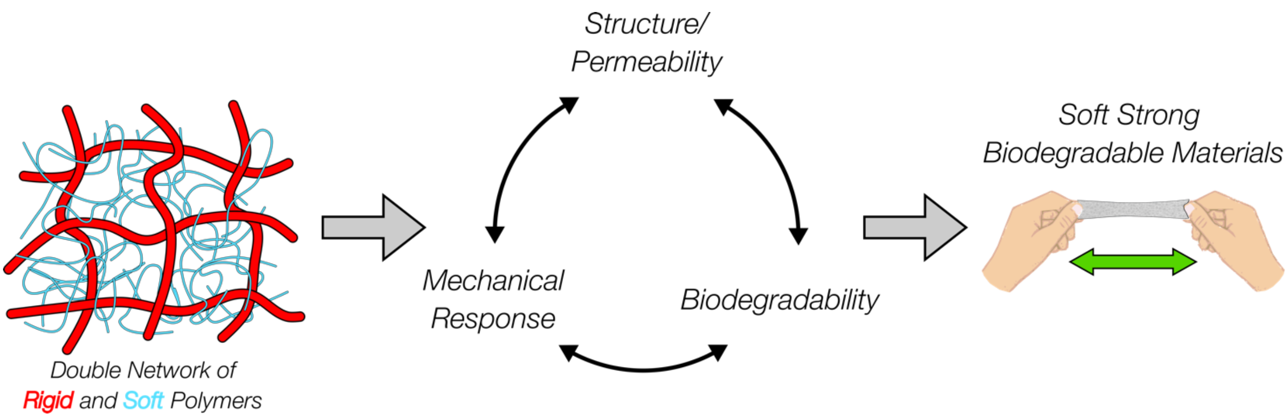
Dr. Anders Aufderhorst-Roberts (University of Durham)

Dr. Natasha Shirshova (University of Durham)

Dr. Mariam Hussain, Dr. Karolis Vilcinskas and Dr. Nima Roohpour (Reckitt Benckiser)

In nature materials often exhibit incredible mechanical properties that are not reproducible in synthetic materials. Much of these properties arise from the fact that almost all structured biomaterials are composite in nature. In humans, for example, tendons are composed of two polymers: collagen, which is effective at absorbing and dissipating energy but largely inextensible, and elastin, which is extensible but poor at dissipating energy. In this project we will seek to design and mechanically test **soft multi-component materials that can match, and potentially exceed, the capabilities of synthetic rubbers.**

To address this problem, we will leverage a technology known as double network hydrogels. Here, two co-entangled polymer networks are co-assembled in water. The individual material properties of each polymer diametrically opposed and synergistically support each other. A rigid highly crosslinked network acts as a tough scaffold within which a second physically crosslinked ductile network is assembled. Under deformation or tension, the ductile network dissipates energy through reversible bond rupture so that the rigid network is protected from fracture.



While hydrogels are typically considered weak materials, this mechanical synergy enables them to be remarkably strong. In this project - supported by Reckitt - we are seeking to synthesise hydrogel composites and optimise their material properties to meet the requirements of different products within their portfolio of brands for health, hygiene, and nutrition applications. Through design, synthesis, and testing (including mechanical testing and biodegradability assays) the student will investigate how controlling the microstructure and assembly conditions of double networks can be conceived as a route to creating strong biodegradable alternatives to soft, synthetic materials.

To tackle this challenge the student will receive training in polymer synthesis, modification, and characterization. This will include linear and nonlinear mechanical testing (tensile testing, rheology) and microstructural analysis. There will also be an opportunity for a 2-3 month internship at Reckitt's Hull Innovation Site. As well as addressing fundamental questions about the relationship between microstructure nonlinear mechanics of soft materials, the project is well-suited to students considering a career in industry as it will directly involve input and support from our industrial partners.