Engineering symbiotic behaviours between bacteria and stem cells

Our aim is to use bacteria to understand stem cell behaviour and engineer artificial stem cell niches. Our inspiration partly lies in what might have happened long time ago in natural evolution when prokaryotic cells became endosymbionts with the eukaryote and mitochondria appeared. We want to use bacteria to help us develop novel tools to understand stem cell behaviour, and hence to enable stem cell technologies in the long term. Stem cells hold the key to underpin many biotechnological challenges in the 21st century. However, our inability to control stem cells *in vitro*, out of their natural niche, limits our understanding and hinders potential applications. The stem cell niches are very complex requiring blood and nerve supply, cytokine and chemokine cues and cell-extracellular matrix and cell-cell control. Current approaches rely on complex cocktails of soluble growth factors to control stem cell growth and function. These factors have limited success in controlling growth and use expensive and broad acting steroids and growth factors to push differentiation. A few years ago, a new vision emerged that we have been central to – that of changing the synthetic matrix the cells are grown on to provide the missing cues to help control stem cell behaviour. In these approaches, synthetic biomaterials are functionalised with a broad range of proteins and growth factors that provide cues to direct cell behaviour. Now, even these 'new' technologies need to be radically rethought to help allow us to bioengineer fully functional in vitro stem cell niches to allow us to understand these important cells.
These external cues used to direct stem cell function rely on 'existing molecules', such as growth factors and proteins. We want to engineer bacteria to direct the evolution of current biology and identify super-proteins which will optimise control of stem cell behaviour. We want to combine these super-proteins with synthetic materials to revolutionise the field of stem cell biomaterials. In addition, we want to engineer non-pathogenic bacteria that will work as drivers of stem cell behaviours by expressing these super-proteins – a truly symbiotic relationship for bacteria to direct stem cells towards desired lineages.