Stevens Institute of Technology
Nanotechnology
Graduate Program

Engineering cellular function in 2 and 3 dimensions

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Cell engineering uses designed environments to investigate and manipulate cellular function. The tools used - include modified interfaces, microfluidic systems and artificial particles. The latest application of these tools is to guide stem cell differentiation. Recent progress on the tools side have included the use of electron beam writer to create nanometric surface features and manipulations of the physical state of the artificial ECM surrounding the cells being investigated. One of the challenges we are facing is to manipulate stem cells with a minimum of intervention - our recent finding point to the role nanometric features could play a role in defining the direction stem cells differentiate into - a slight degree of disorder on the background of an ordered arrangement of 80nm wide pitted features switched mesenchymal stem cells towards the bone progenitor route. We showed the formation of nodules and ECM calcification by cells which had not been exposed to steroids, simply by growing them on polymers imparted with slightly disordered nanofeatures. In order to recreate a tissue -one is faced with the challenge that most are three dimensional and contain multiple cell types. The extreme accuracy which is needed to define cell populations can only be achieved by using electron beam fabrication - but this technique is not easily translated into the third dimension due to the very limited depth of focus of these systems. We are therefore developing means to take patterned thin sheets to the third dimension by rolling, and layering. We have demonstrated that this allows one to exploit the effects nano/micro-patterned surfaces have for building complex tissues in a defined 3-dimensional environment.

Mathis O. Riehle did a Diploma and a PhD in Biology at the J W Goethe University Frankfurt. He is Reader (Associate Prof.) in Cell Engineering at the Institute of Biomedical and Life Sciences at the University of Glasgow, where he is also Director of the Centre for Cell Engineering (CEE). The focus of his research is the interface between cells and materials in its widest sense using surface engineering, cell biological methods, and a wide array of microscopies. Questions addressed at the moment are: what is the influence of mechanical surface features on cells; how does nanometric topography work; how do the influences of 2D nanotopography translate into 3D, and how could nanotopography by used for tissue engineering; what is the chemical, and physical nature of the interface? We are also developing devices to test the toxicity of nanoparticles on lung epithelia. The development of biomimetic surfaces at the nano- and the microscale as well as investigations into cell motility, mechanotransduction and the guidance and influence designed substrata have cell behaviour are being funded by the European Commission in 4 research programmes. Dr Riehle is also part of the editorial boards of 3 journals (IEEE Transactions in Nanobiotechnology, Biointerphases, and European Cells & Materials).

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