Centre for BioSystems Science and Engineering

THESIS COLLOQUIUM

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MMCR
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Lab-On-Chip Platform For Stem Cell Differentiation In Regenerative Medicine

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Biological cellular system can be considered as a complex physico-chemical reactor, which manifests adaptive changes towards external biophysical dues. In order to understand the biological response at different abiological cues and how these changes occur internally to the cell, it is critical to have a close monitoring system. Microfluidic devices provide a unique platform to study many of the intracellular processes alongwith the cellular response. A cornerstone of biomicrofluidic studies are based on cell culture techniques coined with cellular engineering, i.e., the ability to grow biological cells outside the living system within a physiological simulated condition. In comparison to unconventional micro-cultures, conventional macro-culture approaches are often too naïve to provide realistic data. Biomicrofluidics offers an opportunity to bridge these two extremes by using lab-on-chip concept, implementing an integrative approach of using biomaterials and biologically inspired structural designs, together to mimic the physiological microenvironment of cells, in vitro.

The experimental plan of the present thesis work is based on applying shear and electric field on myoblast, hMSc and blood cells. The former two were chosen as they exhibit some degree of plasticity. The cells were also given cues from biomaterials along with shear and/or electric field to probe into the influence of biophysical cues.

Chapter 1: The flow induced shear stress is regarded as one of the most abundant and influential biophysical cue to decisively settle the physiological changes in the cultured cells. While experimenting such altered cellular response due to applied flow, the thesis work demonstrates the intriguing synergistic effect of shear stress and spatial allowance. The mouse myoblast precursor cells undergo myotube formation.

Chapter 2: In this work, a novel strategy has been developed to integrate microfluidics and biomaterials. The study has been conducted on cellular differentiation by influencing the cells with physical cues given by the biomaterial composites along with mechanical stimulation due to shear flow. This generates changes in the cellular functionality, which can facilitate the applications of regenerative medicine. This technique will have enormous potential towards making decision to choose implant materials. In static culture, both the MWCNT and nHA nanoparticle reinforced polymer have manifested almost similar degree of differentiation. But application of shear has brought perceivable differences in osteogenesis and the composites with nHA are more suitable to exhibit high degree of osteogenesis.

Chapter 3: It is crucial for an implant material to be hemocompatible along with desirable cytocompatibilty. Ultra high molecular weight polyethylene (UHMWPE) composites were tested by using on-chip hemocompatibility microfluidic devices for assessing the blood cell morphology, platelet activation. Nanoparticle reinforced polymer composites were more efficient in resisting thrombus formation, which qualifies them to be designated as a successful implant-material.

Chapter 4: The thesis work has investigated the intriguing synergistic effect of electric field towards differentiation of myoblast cells cocultured with stromal stem cells, using an artificially created culture system with inbuilt electrodes. Despite being the precursor cells of striated muscles, myoblasts can manifest non-muscular transdifferentiation under suitable chemokine signaling. The novelty of this work lies in targeting to establish the phenomenon of transdifferentiation of cells under potent influence of external cues.

The interdisciplinary concept of biomicrofluidics is continuously maturing and this demands the development of novel strategies to exemplify accurate outcomes regarding cell based studies. On bringing the biomicrofluidics technology in the field of regenerative medicine, the prospect regarding prognosis of diseases will increase as well as the distress of treatment-unresponsive degenerative diseases will decrease. The aspect has been highlighted in the scope for future work.

For more information depicting the research

(http://www.be.iisc.ernet.in/seminars.html)