東北大学大学院歯学研究科
インターフェイス口腔健康科学
第47回学術フォーラム
Forum for Interface Oral Health Science

Tissue engineering using nanotechnology

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ニコライ先生は、生体工学（ティッシュエンジニアリング）に利用される担体（スキャフォールド）開発が専門分野であり、特に生体材料の表面形状が細胞増殖と分化に与える影響に関する研究では世界トップレベルの業績を輩出しておられます。今回の講演では、半導体生産のリソグラフィー技術を応用した、サブミクロンオーダーの超精密表面修飾を施した生体親和性材料など、最新の研究成果についてレクチャーしていただきます。

ABSTRACT: When designing and fabricating scaffolds in regenerative medicine, it is critical to assess the effect of the surface topography and chemistry and how these results can be realized in a suitable 3D environment to support tissue regeneration. In the first part of my talk I will discuss the technology developed in Glasgow to micro- and nanopattern substrates to influence cell behaviour. The second part will describe how this topography can be combined with chemical surface modification in a combinatorial manner to assess the combined cues. And finally I will discuss how our findings can be realised in 3D to address the tissue requirements for the scaffold design and function.

For several decades, it has been known that cells respond significantly to the topography of the surface on which they are adhering. Although the original findings were on the micrometer length scale, it has become increasingly clear that submicron features play an important role in the regulatory response of the cells. Over the years, we have developed a flexible, yet robust, lithography technique based on electron beam lithography whereby we can produce surfaces with highly regular arrays of 100 nm diameter nanodots on a 300 nm pitch. In particular, we have found that human mesenchymal stem cells are sensitive to variations as small as 20 nm in the fidelity of the pattern. When cells are cultured on surfaces with a deliberately introduced irregularity of 50 nm to a perfect pattern the cells specifically differentiate towards bone forming cells. This is not observed for cells on either flat substrates or surfaces with a high degree of order. In a different system we have explored the interplay between surface topography and chemistry in a dual gradient model. Here substrates had a topographical gradient running along one axis of the substrate and a chemical gradient along the other axis. With this kind of tool we have demonstrated that an ideal combination of topography and chemistry exists for a given cell type. Finally, by combining our knowledge on micro- and nanotopographies we have developed a 3D scaffold platform for tissue regeneration.

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