3D nematic-like tissues : Mechanical and electrical constraints to orchestrate muscle cell differentiation.

Keywords :
Mechanobiology, 3D tissues, nematic

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Scientific context

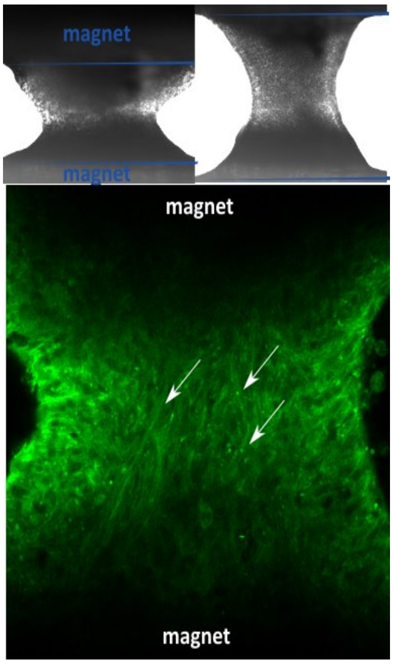

Figure 1 : Myoblasts cells trapped between two micro-magnets and stretched. Fused cells are visible (white arrows).

Cell-generated forces in tissues allow biological tissues to contract, stretch, align and organize themselves, especially during muscle formation. Indeed, muscles have a fascinating multi-scale architecture that supports both their active and passive functions. This complex architecture hinders the creation of artificial muscles. The impact of physical constraints on muscle cell differentiation is therefore fundamental to understanding muscle pathologies. In addition, muscle cells reveal as model nematic cells [1,2], they are elongated and alignment is promoted. This property reveals as fundamental in the major step of muscle differentiation which is fusion.
In recent years, we have developed an original approach based on the use of magnetic nanoparticles [3,4,5,6] to create 3D functional muscular tissues. Magnetic nanoparticles penetrate into cells to endow them with magnetic properties, so that they can be remotely stimulated by a magnet to form multicellular aggregates of controlled size, shape and content, and deformed to access their mechanical properties [7] or to control cell fate [4,8].

By trapping cells between two facing micromagnets, we are able to apply our approach to muscle progenitor cells, to align and fuse them.

Internship project

The aim of this internship is to refine this model by adding a new physical constraints to drive differentiation : electrical stimulations. *In vivo*, muscle are activated through motoneurons connections. The impact of electrical activity on muscle functional differentiation is well documented but its correlation with mechanical forces has not been explored yet. In this project we will used optogenetic cell line to have spatially-resolved stimulation.
Depending on the relative orientation of electrical and mechanical stimulation, competitive effects may be obtained driving a Frederick-like transitions in these 3D tissues.

This is a synergistic project that will be carried out in close collaboration with Cochin Institute and Institut Curie. It will use a variety of techniques including confocal and two-photon microscopy, mechanical manipulation, magnetic forces, cell biology.

The Complex Systems Laboratory (MSC-UMR7057) in Paris is a renowned interdisciplinary research centre with expertise in life sciences, physics, chemistry and engineering.

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[8] I. Nagle et al. preprint (2024)