TU/e MICRO SYSTEMS

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

Generating fluid flow in cell culture well-plates
Using Magnetic Artificial Cilia

MSC Thesis

Background

Cilia are slender microscopic protrusions of biological cells acting both as actuators and sensors – especially for generating and sensing fluid flow. Cilia are present in most tissues in humans and are responsible for numerous biological processes (Fig. 1). For example, they can sweep mucus to clear wind pipes and the lungs or drive fluid flow during embryonic formation.

Inspired by these biological cilia, we are developing *artificial cilia* to manipulate fluids on a small scale (Fig. 2). For example, the artificial cilia can create flow in microfluidic devices, transport micro-particles, mix fluids or sense forces at the micro-scale. We have developed microfabrication techniques to make magnetically actuated artificial cilia for these applications.

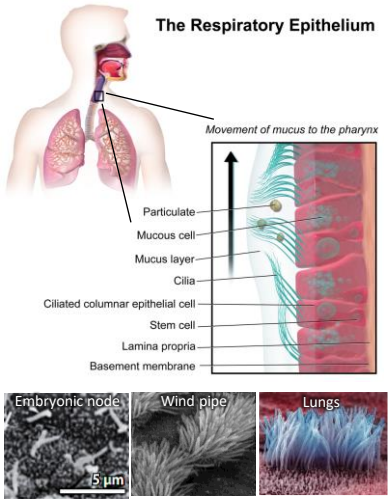

Fig.1 - Cilia are microscopic hair like structures that function as actuators, e.g. for flow generation, or sensors, e.g. sense fluid forces, in many biological systems, including our own body.

Project description

The researchers in the *Microsystems* group (Mechanical Engineering) and the *Soft Tissue Biomechanics and Tissue Engineering* group (Biomedical Engineering) have incorporated millimetre-scale artificial cilia in a single well in a conventional cell culture well-plate to generate a flow of cell culture medium on top of the cells, as shown in Fig.3 [2]. This flow can be tuned to

- Mix the liquid in the wells to refresh nutrients in contact with the cells, and
- Apply shear stress on cells.

The **goal** of this project is to **create similar flow patterns in different wells of a multi-well plate using artificial cilia**.

To achieve this goal, the student will follow these steps:

- Design an artificial cilia array and a magnetic set-up
- Fabricate artificial cilia using microfabrication techniques
- Build a magnetic set-up
- Run tests; Visualize and quantify the fluid flow

At the end of this project, the student will learn the following skills:

- Computational simulation of the magnetic field
- Microfabrication techniques (soft lithography)
- Perform fluidic experiments
- Optical microscopy

The student will be part of the Microsystems group and will collaborate with a student from the biomedical engineering department who will perform computational fluid flow simulations and cell culture experiments.

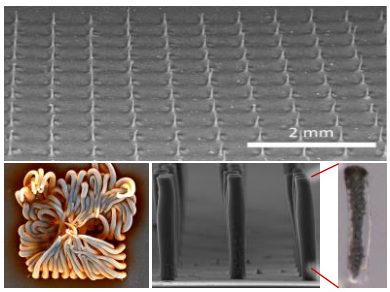

Fig.2 – Magnetic artificial cilia array is fabricated in the lab and can be actuated in a magnetic field [1].

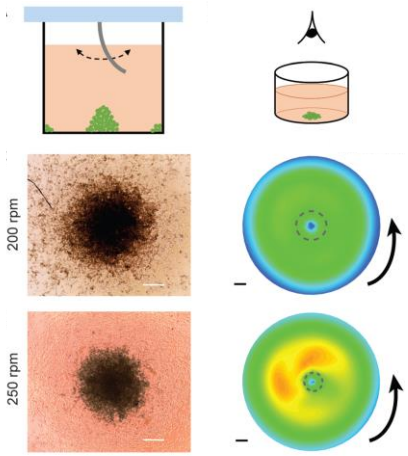

Fig.3 – Magnetic artificial cilia can generate fluid flow in cell culture well-plates. The bottom left pictures show breast cancer cells in a well and the bottom right picture shows the fluid shear stress on the bottom of the well at different rotation speed of the magnetic artificial cilia [2].

Reference

[1] Den Toonder, Jaap et al., eds. Atlas of cilia bioengineering and biocomputing. River Publishers, 2018.
[2] Saberi, Aref et al. "A stirring system using suspended magnetically-actuated pillars for controlled cell clustering." Soft matter 15.6 (2019): 1435-1443.