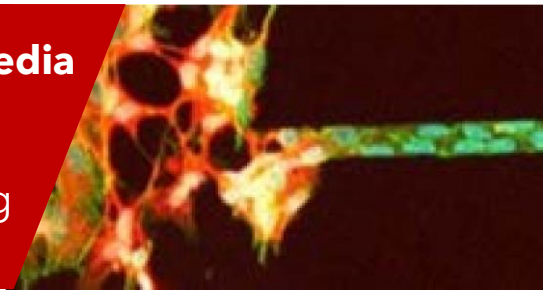
Pump design and integration for automatic media exchange in Brain-on-Chip applications

Master project | Neuro-Nanoscale Engineering



Introduction | Neuro-Nanoscale Engineering

In the Neuro-Nanoscale Engineering group we investigate micro-environments for neuronal cell culture by using nano-and microfabrication methods to create Brain-on-Chip devices. One valuable application area of such devices is the development of new physiologically relevant drug testing models for neurodegenerative disease. By incorporating neuronal differentiation in 3D in these Brain-on-Chip systems, the neurons are allowed to develop in a clinically relevant environment. This improves predictions made about physiological processes based on *in vitro* cell cultures. However, sustaining 3D cell cultures for the amount of time necessary for neuronal differentiation, that is weeks to months, is not trivial. Therefore, our group has previously developed a Brain-on-Chip based on a so-called microbioreactor.[1,2] In this system, a 3D neuronal culture can be sustained in the culture chamber, while media is exchanged via the microfluidic chamber.

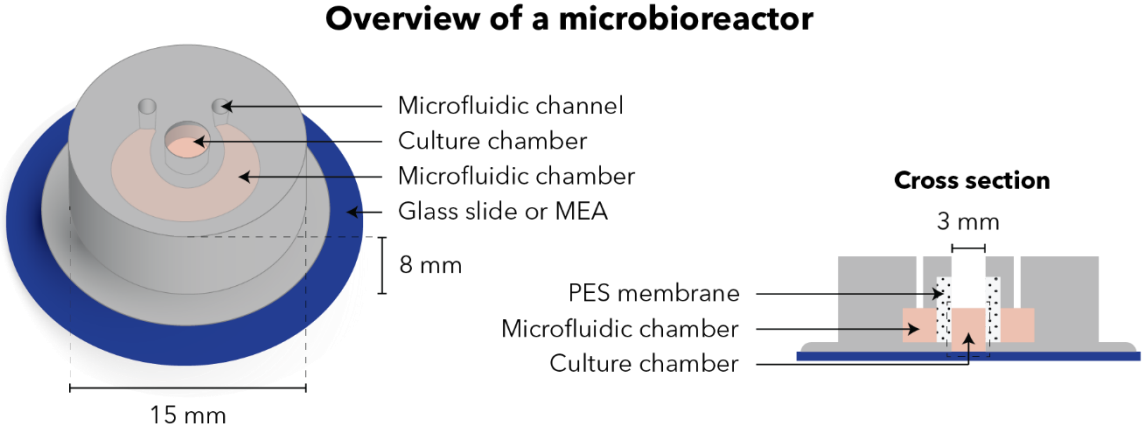


Figure 1: Schematic overview of a microbioreactor

Project | Optimizations of 3D culture system design and integration

During initial cell culture experiments within our microbioreactor, it came to light that some problems arise due to the evaporation of the cell culture media. In addition, thus far the full potential of the microbioreactor has not been employed as the microfluidic chamber has not yet been attached to a pump for automatic media exchange. This would be preferable to minimize disturbances of the 3D neuronal culture as much as possible. It would also make these long-term culturing experiments less labor intensive and more cost-effective. There is thus still some room to improve this culture system.

Goal | Milestones and achievements

In this project, the student will aim to improve our 3D culture system. The goals of this project are:

1. Analysis of the performance and the flow through the microfluidic channel (media exchange speed).
2. Optimization of the microbioreactor device for long term cell cultures (e.g. prevent excessive evaporation).
3. Evaluation of the performance of the optimized microbioreactor device (if time allows and the student is interested in cell culture work).

References

1. Schurink, B. & Luttge, R. Hydrogel/poly-dimethylsiloxane hybrid bioreactor facilitating 3D cell culturing. *Journal of Vacuum Science & Technology B, Nanotechnology and Microelectronics: Materials, Processing, Measurement, and Phenomena* **31**, 06F903 (2013).
2. Bastiaens, A. J. *et al.* Advancing a MEMS-Based 3D Cell Culture System for in vitro Neuro-Electrophysiological Recordings. *Front Mech Eng* **4**, 1–10 (2018).

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