Moonshot: Nanofabricating neural networks

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Nanofabrication can help to emulate natural intelligence[1]. Forward-engineering brain gained enormous momentum but still falls short in effective human neurodegenerative disease (NDD) modelling[2]. Realizing that NNDs are devastating, we need better technological solutions in understanding the mechanism causing NDD.

We believe self-organization of stem cells is key to advance NDD models[3]. Even though we are now in the position of growing human-derived neurons in 3D and investigate their behavior by electrically integrated devices such as multi electrode arrays (MEAs)[4], the coordinated assembly of many other supporting cells with their protein-based fibrous connected features is still largely missing. Current networks of neurons show a biology, which represents functions similar to those reported for fetal human brain[3]. Here, I present a brief historical overview and novel perspectives in the eminent works, which have been provided in this field of human brain modelling to shine light on *in vivo*-like message passing from neuron to neuron in a dish. Previously at this conference, we demonstrated that surface topography contributes to the patterning in network formation[5],[6],[7]. In addition, we showed that the integration of precision tools with single cells inside of a neural network is possible[8]. This will allow us to study evoked signals like the processes occurring in the brain when receiving input stimuli via our senses. Subsequently, the interconnectivity between the neurons in such neural networks emerge higher functions by the principle of energy minimization[9]. While brain organoids are still in its infancy, microchips can already merge stem cell tissue engineering, microfluidics and nanofabrication into one platform as demonstrated by our own efforts in bringing the nervous system on a chip[10]. Hence, we are now well-prepared to launch a moonshot applying nanofabrication neural networks in modelling human brain functions.

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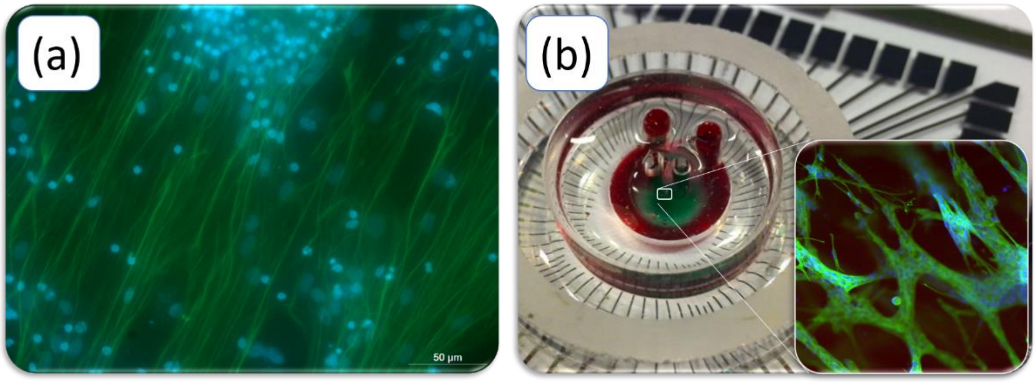

Figure 1: (a) Polydimethylsiloxane (PDMS) nanogrooves yielding aligned outgrowth in rat cortical cell culture, image courtesy: S. Xie, University of Twente, 2013 and (b) microbioreactors facilitating 3D neuronal cultures on multi electrode arrays, image courtesy: B. Schurink, University of Twente, 2013 and insert: J.-P. Frimat, Eindhoven University of Technology, 2016.