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Parallelized 3D Blood Vessels-on-a-Chip for Vascular Disease Modelling

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The aim of this project is to develop a three-dimensional, highly parallelized blood vessel-on-a-chip system that integrates endothelial cells, smooth muscle cells and blood, and that can be cultured for weeks to months under continuous perfusion.

The first part of the project contains setting up a complex 3D blood-vessel on a chip. The current vascular models are "2D"-systems that consist of only one cell type, which are cultured under static conditions. Whereas the in vivo blood vessels are more complex than that. The in vivo blood vessels consist of endothelial cells, as well as pericytes and smooth muscle cells and are undergoing a constant shear stress. The system we will design will consist of a Polydimethylsiloxane (PDMS) chip in which a 3D circular lumen is formed by viscous fingering in collagen-I, in which several cell types can be cultured simultaneously. This system can be used for exploring the effects of certain cytokines (such as TNF-α) on the endothelial barrier or even other cell types in the vascular channel. This can entail the setting up of systematic blood runs to observe thrombus forming, as well as microbleeding and the effects of vascular leakage on surrounding tissues.

The second part of the project deals with increasing the throughput of the develop blood vessel-on-chip systems. The current blood vessels-on-chips are cultured in parallel with a maximum of approximately 8 chips simultaneously. This limited throughput is a significant bottleneck in modelling vascular disease in our systems, because it prevents us from studying chronic aspects of vascular disease, and it prevents us from testing every relevant experimental condition in collaborative projects with biomedical and pharmaceutical end-users (for example different cells types/exposure times/culture conditions etc.). We therefore will develop a system that allows the simultaneous culture of at multiple Blood Vessels-on-a-chip on the 'Translational Organ-on-Chip Platform' (TOP) https://top.hdmt.technology/.

Current 3D-blood vessel chip design