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Vasculature and flow in microfluidic systems

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Vasculature and Flow in Microfluidic Systems

1. The inclusion of vasculature and flow dynamics in organ-on-a-chip models is an important step towards physiological relevance by recapitulating drug resistance mechanisms and inflammatory responses. (This thesis)
2. Organ-on-a-chip systems, such as the microfluidic platform of this thesis, offer a scalable platform for high-throughput drug screening while maintaining complex biological relevance. (This thesis)
3. Automation and robust data analysis pipelines are critical for scaling organ-on-a-chip technology to high-throughput drug screening applications, reducing costs and accelerating drug discovery. (This thesis)
4. The translatability of organ-on-a-chip findings to clinical outcomes remains a key challenge; bridging this gap could eventually replace animal models in preclinical research. (This thesis)
5. To operate organ-on-a-chip devices, there is often a need to connect tissue culture media reservoirs, tubing, and pumps, resulting in systems with many more moving parts and increased complexity. (Skardal 2024) Gravity driven flow in microfluidics eliminates the need for complex pump and tubing systems.
6. Replicating vascular hierarchies is essential, as arterioles, venules, and capillaries differ in endothelial phenotype, flow and pressure, matrix composition, and supporting cell types. Addressing these unmet needs will significantly advance our ability to support functional tissues with efficient flow and transport, like in vivo conditions. (Shin et al. 2025) The microfluidic platform of this thesis actually allows tuning of flow, matrix, and co-culture conditions to approximate key aspects of distinct vascular beds.
7. While a complex multi-organ chip can provide a more physiologically relevant scenario for drug toxicity testing, a balance between feasibility and complexity of the system should be taken into account during development. (Ma et al. 2020) While challenges remain, advances in plate-based systems, like the microfluidic platform of this thesis, and imaging pipelines are addressing these needs. For HTS, single-tissue models with tunable complexity offer a practical balance between feasibility and relevance.
8. Chemoresistance in PDAC is multifactorial as a result of the interaction among pancreatic cancer cells, cancer stem cells, and the tumor microenvironment. (Zeng et al. 2019) Interstitial flow, which was not mentioned in the paper, also plays a critical role by influencing drug distribution and cellular responses. Accurately modeling the tumor microenvironment and chemoresistance therefore requires incorporating both biological and biophysical factors like flow dynamics.
9. Have no fear of perfection, you'll never achieve it. (Marie Curie)
10. Smart people learn from their mistakes, wise people learn from others' mistakes. (Fraser C. Robinson)
11. An ounce of practice is generally worth more than a ton of theory. (E.F. Schumacher)