

Deciphering the human blood-brain barrier with in vitro physiological models

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The brain, the most enigmatic organ of the human body, is effectively protected by the blood-brain barrier (BBB), which functions as its administrative center. This complex and dynamic interface of the central nervous system (CNS) separates the brain from the circulatory system and other organs, playing a crucial role in safeguarding brain health. However, the BBB also presents challenges by impeding drug transport to the CNS, complicating the treatment of brain diseases. Despite the BBB's significance, our understanding of the fundamental processes underlying its development, maintenance, and interaction with other bodily systems remains limited. Impaired BBB function has been associated with various neurodegenerative and neurodevelopmental disorders, as well as traumatic brain injury, stroke, and brain malignancies. One major obstacle to effectively treating neurological disorders is the inability of many drugs to penetrate the BBB. This challenge is compounded by the fact that many of these disorders are not yet curable, and our current knowledge about them is incomplete.

At the Mustafaoglu Lab, we are addressing these challenges by developing innovative microfluidic systems that mimic the BBB under physiological conditions, both in healthy and diseased states such as epilepsy, brain cancer, and fetal familial insomnia. Our research involves creating new protocols for differentiating stem cells into neurons and brain endothelial cells. Additionally, we design and fabricate novel microfluidic devices capable of applying shear and tensile stresses to cells, simulating physiological vascular movements in the brain. By leveraging these state-of-the-art bioengineering platforms, we aim to deepen our understanding of the human BBB and its implications for health and disease. Ultimately, our goal is to develop unique nano-shuttle systems that can effectively deliver drugs to the brain, offering new avenues for treating and potentially curing various brain diseases.