A MICROFLUIDIC DEVICE TO STUDY AXON GROWTH AND GUIDANCE

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Abstract

The human brain is an extremely complex and highly dynamic organ that contains billions of cells and trillions of connections. During development, each neuron migrates to its intended location, differentiates into a specialized neuron type, sends out processes to appropriate targets, and effectively communicates with its surrounding environment. The axon can travel long distances through dense tissue before connecting to the correct target. This process results in a highly organized and communicating network. Growth and change does not occur solely in the developing brain since the mature brain is highly dynamic and neuronal reorganization is integral to brain function and is the basis for the learning process. Having a detailed knowledge of the mechanisms of axon growth and guidance is essential for understanding the nervous system's development, functioning, and to effectively treat damages of the nervous system by injury or disease.

Studying axon guidance by diffusible or substrate bound gradients is challenging with current techniques. In this study, we present two microfluidic devices to study axon guidance. The first device was designed specifically for the study axon guidance for neuron types that can be obtained in large numbers. In this device, neurons are seeded into a micro-channel and pack onto the surface of a collagen gel. Axons grow into the matrix in three dimensions, and a gradient of chemoattractant, orthogonal to the direction of axon growth can direct the axons. The average turning angle of each axon can be measured to quantify the guidance. Significant angles have been measured in the presence of a gradient of chemoattractant.
The second device was developed for the study of corticospinal motor neurons (CSMN), which are part of the motor circuit. Since these neurons are involved in a neurodegenerative disease, a better characterization of these cells is essential and may lead to new therapeutic options.

Both devices occupy a unique position at the interface of neuroscience, developmental cell biology, advanced biomaterials, and microfluidic technology and have a very strong potential as new tools for neuroscience research.