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A Single-Cell Microfluidic Device for Studying Leukemia Cell Proliferation

We develop a novel mother machine-like microfluidic device designed to track the proliferation of single mammalian cells via live-cell microscopy. Although numerous microfluidic devices have been developed to study cell proliferation at the single-cell level, most of them are optimized for bacteria, which do not require particularly demanding growth conditions. We present a device specifically designed to track the proliferation of human primary T cells, featuring an array of microchannels that trap cells without altering their physiological growth conditions. Each microchannel allows a single cell to enter and proliferate while maintaining a continuous flow of nutrients, ensuring long-term monitoring over multiple generations. The channel geometry, optimized through computational fluid dynamics simulations, ensures stable trapping conditions while preserving cell viability. Here we show the advantages of this system in characterizing the processes of cell growth and division. Indeed, through time-lapse microscopy it is possible to identify and characterize each individual cell within the channels, measuring key parameters such as cell size at different cell cycle stages and duplication time. In particular, we first test the device reproducing and extending the results we found in a previous work, where we showed that proliferating human Jurkat T cells exhibit symmetric volume division. Then, we use the mother machine to follow the growth and division of human primary T cells at single cell level by measuring: (i) duplication time, assessing the effect of growth in isolation; (ii) cell size dynamics, from birth to mitosis, to determine their growth mechanisms; (iii) the effect of shear stress on cell growth by varying the inclination of trapping channels Overall, our device design can be easily adaptable and can be used to study different cell types and sizes while maintaining the same high trapping efficiency.

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