Microcage array promises parallel physical analysis of single cells

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Video Abstract

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Abstract

These metallic pillars are helping researchers understand the physical properties of biological cells like never before. Individually controlled electronically, they're able to stop cells in their tracks and make them spin using dielectrophoretic forces. This microscopic line dance provides bioelectric information that could help researchers analyze unmarked single cells on a chip—all without handling them directly. The so-called electrorotation system works like this. Cells suspended in a fluid flow through the device at a given rate. With no electric field applied, the cells simply slip past the entrance and exit electrodes. But applying a high-voltage signal to the exit posts creates an impenetrable force field. Applying the same signal at the entrance completes the trap: no cells in and no cells out. One at a time, the system captures up to 39 cells. Once all the traps are filled, a rotational signal is mixed in with the trapping signal. That signal generates a torque on the cells that causes them to spin. Gradually, the frequency of the rotational signal is ramped up, and the speed of the spinning cells is recorded. The result is a signature unique to the type of cell being probed. The research team performed experiments on 4 different cell lines to test their microcage array: HeLa cells, human embryonic kidney cells, human neuroblastoma cells, and human immortalized T lymphocytes. All except the lymphocytes were trapped in systems featuring a wide interelectrode gap of 40 or 80 microns. These small cells required a much smaller gap to create an electric field strong enough to trap them. Additionally, the electrorotation signature of the neuroblastoma cells was determined for the first time. The principles of electrorotation aren't new. What the new system provides is the potential for higher throughput. Instead of processing 12 to 20 cells per hour, as in previously presented solutions, this new system with 39 traps has the capacity to process up to 600 per hour. Ten times more cages could easily be placed on the same device in the next generation of the technology to provide even higher throughput. These and other improvements could help make the electrorotation system much more robust, helping researchers analyze cells for biomedical applications faster and more reliably.