Taking cells for a spin

Microvortices and optical trapping could be used to study the effect of rotation on cells

At the University of Washington in Seattle, scientists have set a speed record. They found that single living cells twisted as much as 200 times a second when optically trapped in microvortices they created in microfluidic structures. According to researchers Daniel Chiou, that rotation rate is a record for single mammalian cells.

This miniature merry-go-round isn’t for fun and games, however. “This ability, we believe, may allow us to study the effect of rotation on the behavior of single cells, a regime that has not been studied much in the past,” Chiou said. Studies have shown that cells that adhere, such as endothelial cells, change behavior and function as a result of hydrodynamic forces. This technique may be useful for studying the hydrodynamic forces on other cells, such as those flowing through arteries.

Creating the microvortices required structures with stable vortices of fluid rotation that, ideally, are unaffected by changing fluid flow rates. After analyzing various structures, the researchers concluded that the best arrangement...
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consisted of a chamber in the shape of a diamond with three smaller diamonds placed at its corners that was attached to a laser channel. They used photophysical techniques to construct such a microfluidic shape.

The overall structure had a height of 75 μm, the rectangular duct was 100 μm wide, and the three smaller diamonds were 70 μm wide. Fluid flowing through the channel formed three microvortices, one in the center of each of the small diamonds. This arrangement produced a slower rotation and fluid flow than other arrangements that were tried, but the researchers felt that the increase in the vortex’s stability was worth the decrease in velocity.

To investigate the motion of microparticles and single cells, they injected either microparticles or cells into a fluid flowing through the microstructure. They then optically trapped and positioned the moving particles within a microscope using the 1064-nm line of a Spectra-Physics Nd:YAG laser. An argon-ion laser from the same company provided a 488-nm line for single-molecule confocal detection.

Measuring particle rotations required an optically visible mark. The investigators marked the microparticles using a

University of Washington researchers constructed diamond-shaped chamber designs to generate microwortices (top panel). The resulting microwortices (bottom panel) were visualized by tracking of the flow lines by fluorescent beads. This could be used to split cells and nanoparticles.