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Mobile magnetic traps for cell manipulation

R. SOORYAKUMAR, The Ohio State University

Highly localized magnetic field gradients in the vicinity of patterned ferromagnetic wires and disks provide a planar template to assemble labeled cells or magnetic micro-/ nano-particles onto designed arrays. By combining the platform with externally controlled weak (<100 Oe) fields, cells are transported across surfaces with programmable directed forces that are gentle enough to not produce damage. In addition to manipulating immunomagnetically labeled biological cells, magnetic microspheres that act as magnetically actuated miniature force transmitting probes navigate fluid-borne unlabeled cells with micrometer precision. The versatility of this approach is evident when the magnetic forces are tuned, enabling the Brownian motion of microscopic objects be controlled. Central to these observations are the simple methods to create, with nanoscale precision, highly confined field gradients. In addition to the convenience of optical microscope observation and advantage of suppressing randomizing thermal fluctuations of fluid-borne cells, development of such mobile magnetic traps will provide real-time analysis of living cells through direct manipulation that offers much more accurate selection than data-averaging over a population of cells.