LAB-ON-A-CHIP: Applications to Cell Biology

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Cell cultures and cell-based assays are an essential tool for drug discovery, tissue engineering and stem cell research. Although studying cell cultures has become an essential tool in cell and molecular biology, medicine and biotechnology, it has fallen far behind in the pace of progress as demonstrated by genome sequencing, imaging probes, and high-throughput testing of biochemicals. One major drawback of employing conventional cell cultures is that they do not consider adequate nutrient supply, fluid mechanical shear forces, waste removal, and constant temperature. It is well known that cell responses are profoundly influenced by the cellular microenvironment or biological niche. Additionally using classical cell-based assays, particularly in combination with prevailing screening technologies, employ immortalized cell lines exhibiting phenotypes that differ significantly from those found in human pathology. Consequently, to gain a deeper biological understanding of the complex cellular interactions with their microenvironment, it is necessary to first make progress in experimental devices and analytical methods.

Microfabrication technology has shown potential for providing the next generation of cell analysis tools where large numbers of single cells or small numbers of cell populations can be tested in a cellular environment that better mimics *in vivo* situations. Microfluidic biochips or lab-on-a-chip systems are vital for cell analysis because they allow spatial and temporal control of growth conditions. An important aspect in cell analysis also relates to the ability to investigate dynamic cell responses to changing external parameters. Consequently, to advance cell based *in vitro* methodologies we have developed lab-on-a-chip systems capable of monitoring cellular dynamics continuously and non-invasively in a nanoliter environment under near-native conditions. The Cell-on-Chip system comprises of external pumping and heating stations, valves, injection ports and the microfluidic biochip containing embedded optical and electrical microsensors. The presented work addresses aspects of chip design and sensor characterization as well as their applications to cell biology including nanotoxicology, tumor invasion studies and personalized medicine. The presented technology could, therefore, provide medicine with a diagnostic tool exhibiting better sensitivity, specificity and reliability.