From cells-on-chip towards lab-in-a-cell

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Lab-on-a-chip technology (LOC) has now reached a mature state and is very popular in the fields of life sciences. This success can be explained by the numerous advantages LOC devices bring compared to lab-scale instrumentation. They enable faster, more sensitive and reproducible analysis using lower amount of reagents, solvents or less energy. Besides, microfluidics lends itself well to the realization of complex platforms that integrated either a series of independent but identical devices or a succession of operations. Originally, the development of LOC devices was driven by the field of bioanalysis. Their application has recently been diversified and extended to cellular investigations, field for which LOC devices present additional advantages: a better reproduction of the *in vivo* environment and dynamic culture conditions, and the possibility to combine several steps of culture, treatment and analysis. Microchips enable studies at the single cell level by implementing for instance dedicated structures for cell trapping, but also using more complex systems such as microtissues and small organisms (*C. Elegans*). Lastly, sensors can be added in the microchip for monitoring culture conditions, measuring biological parameters or for cell analysis.

As a next step, we introduce here the concept of "lab-in-a-cell" [1]: the use of a single cell as a minimal and highly confined experimental unit. LOC provides the appropriate format and set of tools for cell experimentation (cell handling, culture, modification, characterization and analysis), and nanoscale tools such as nanochannels, nanopumps, nano-electrodes or nanosensing structures are easily implementable in a LOC device for sub-cellular/intracellular experimentation.

We will firstly discuss the application of LOC devices for cell investigation with different levels of complexities (from a single cell to a small organism), with the pro's and con's of the different approaches. Following this, we will define the concept of LIC and present the minimal platform required for LIC experimentation, e.g. necessary microfluidic tools and operations. Potential examples of this new LIC experimental platform will be discussed as well. We will finally illustrate the LIC concept by describing research conducted in our group and useful LOC tools applicable for LIC experimentation, namely for cell modification, imaging, characterization and analysis.

[1] S. Le Gac and A. van den Berg, *Single cells as experimentation units in lab-on-a-chip devices,* Trends in Biotechnology, 2010, 28, *in press*.