302a Plenary: a Microfluidic Toolbox for Biomedical and Diagnostic Applications

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Complete lab-on-a chip or micro total analysis systems (μ-TAS) require a wide variety of microfluidic components for the completion of complex and challenging medical and biological assays. These components fall into 3 broad categories: sample preparation, sample separation or analysis, and detection. All three areas must be well developed for a complete system. Unfortunately, the challenges for integrating all of the various components can be daunting, especially when multiple physical processes are required, such as: fluidics, electronics, optics, chemistry, and biology. To minimize the challenge, simple solutions that combine processes into one structure must be developed. This report will focus on how simple microfluidic platforms can be used to solve complex problems by combining a series of simple, yet powerful, processes. As part of this work, each area of a lab-on-a-chip system will be explored for how component demands can be reduced and how simple techniques can be used to combine functions into one structure. First, sample separation and analysis tools have made great progress over the past several years and are becoming highly developed. Microchip electrophoresis units are becoming standard in many areas of analytical chemistry. A wide range of other separation and analysis tools have been presented. We have focused on the use of field flow fractionation (FFF) for handling and separating nanoparticles in microdevices. A short review of micro FFF devices will thus be presented as a potential key component in a microfluidic device. Microscale chemical and biological sensors have also been demonstrated for a wide range of applications. In our group, we have focused on using nanoassembled layers combined with microfluidic chips to generate sensing arrays that can be combined with a variety of other microfluidic components. These nanoassembled sensors will be presented and a discussion of how they can be integrated with other microfluidic components presented. Second, complete on-chip sample detection systems have lagged somewhat behind the analysis systems, but they are also becoming readily available. Optical detection components, such as those using fluorescence or absorbance, and electrical detection systems using conductivity or amperometry have been presented by several groups. We will present both simple optical and electrical particle and sample detection components for use with a variety of analytical tools. Third, sample preparation has been the most difficult challenge for a complete μ-TAS. The task is especially challenging since no one process can prepare the wide range of samples that may be encountered. A few generally applicable systems have been encountered and we will present several options for sample preparation including: techniques for DNA extraction and amplification, techniques for filtering and separating out desired components from raw samples, techniques for sample concentration, and techniques for mixing, washing, and purifying samples. Finally, integration of all of these components can be challenging due to the unique fabrication requirements of each component. Also, pumps and other fluid control components must be integrated to move fluids between the various components. Simple schemes for handling this integration along with turning these systems into highly parallel arrays will be discussed.