Micro and Nano Technologies for Cellular Engineering

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The ability to control fluidic, electrical, and mechanical fields using micro and nanotechnologies is enabling key advances in cellular engineering and material discovery. In this presentation, I will address the role of microfluidic platforms in genome engineering and temporal cell analysis. In cellular engineering, a critical step is the intracellular delivery of gene editing machinery and subsequent nondestructive, temporal analysis of cells. Both can be achieved by cell membrane permeabilization, as part of workflows employed in the investigation of molecular mechanisms of disease, pharmacological screening, and development of new therapeutics. Specifically, I will discuss several microfluidic platforms created in my lab, ranging from a fully automated nanofountain probe electroporation (NFP-E) system, which provides *single-cell* manipulation with superior cell viability and efficiency, a 24-well localized cell electroporation device (LEPD), and a live cell analysis device (LCAD) for *nondestructive and temporal* cellular analysis. A critical aspect of the technology is the possibility of perturbing cell state and performing downstream image and molecular analysis. I will present single cell RNA sequencing data analysis to show that microfluidic technology, with localized application of electric fields, leads to significantly reduced cell stress response and much higher control of molecular payload when compared to standard delivery methods. Case studies of gene editing and cell perturbation with siRNAs followed by machine learning image analysis will be discussed.

Biosketch: Horacio D. Espinosa is the James and Nancy Farley Professor of Manufacturing and Entrepreneurship, Professor of Mechanical Engineering, and the Director of the Theoretical and Applied Mechanics Program at the McCormick School of Engineering, Northwestern University. He received his Ph.D. in Solid Mechanics from Brown University in 1992. Espinosa has made contributions in the areas of deformation and failure of materials, design of micro- and nano-systems, *in situ* microscopy characterization of nanomaterials, and microfluidics for single cell manipulation and analysis. He has published over 300 technical papers on these topics. Espinosa received several awards including the Prager Medal from the Society of Engineering Science, the Society for Experimental Mechanics Murray and Sia Nemat Nasser Medals, and the ASME Drucker and Thurston awards. He is a member of the *National Academy of Engineering* (NAE), foreign member of *Academia Europaea*, the *European Academy of Arts and Sciences*, the *Russian Academy of Engineering*, and Fellow of AAAS, ASME, SEM, and AAM. He was the President of the Society of Engineering Science in 2012 and is a member of the IUTAM General Assembly.