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Single cell laser mediated molecule delivery – infrared laser based microinjection

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Single cell microinjection is a powerful technique used to introduce exogenous material into cells and to extract and transfer material between cells. Traditional microinjection is a purely physical mechanism that does not require other compounds, amplifies the physical effects of the injected substances, provides precise volume and timing control for intracellular delivery, requires less material, and facilitates experimental consistency by allowing the untreated cells to serve as the control. However, microinjection is extremely labor intensive and expensive.

This presentation outlines the development of a new laser-based single cell injection method that is inexpensive, user-friendly, rapid, user-friendly, independent of operator skill, and minimized consumables. While previous studies have demonstrated promising results for single cell laser injection using femtosecond lasers, mostly at 800 nm, these offerings are expensive (the laser alone costs ˜$100k) and do not always achieve the users' expectations. On the other hand, 1550 nm fs lasers are almost an order of magnitude less expensive than 800 nm lasers. We previously showed that a 1550 nm wavelength laser permeabilized multiple cells because the greater water absorption induced greater membrane temperature gradients, which enhance membrane permeabilization [2]. This presentation extends this work by targeting a single cell of interest with a 1550 nm commercial femtosecond laser. We summarize the hardware, control software, their integration, innovative beam alignment methods, and preliminary results for propidium iodide and plasmid delivery.

[1] A. L. Garner, V. B. Neculaes, M. Deminsky, et. al, "Plasma membrane temperature gradients and multiple cell permeabilization induced by low peak power density femtosecond lasers," Biochem. Biophys. Rep., vol. 5, pp. 168-174, 2016.
[2] J. Song, A. L. Garner, and R. P. Joshi, "Molecular dynamics assessment of the role of thermal gradients created by electromagnetic fields on cell membrane electroporation," Phys. Rev. Appl., vol. 7, 2017, Art. no. 024003.

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