**Nanoelectronic Tools for Brain Science: Towards Precision Electronic Medicine**

Charles M. Lieber, Harvard University

[http://cmliris.harvard.edu/](http://cmliris.harvard.edu/&) & [http://meshelectronics.org/](https://urldefense.proofpoint.com/v2/url?u=http-3A__meshelectronics.org_&d=DwMGaQ&c=imBPVzF25OnBgGmVOlcsiEgHoG1i6YHLR0Sj_gZ4adc&r=GkVMus8MOTo7sXcBymk89dJHHeQEDLwQsL_d5xV86Uc&m=7Fl_P9_rD1qh1L104hNiXzT4-wtSEZr0-JP-yAru8FE&s=boKb-fzKOtTeYIYBdBqBYbjMiI5Tug1daA9xVhJO6pw&e=)

Nanoscale materials enable unique opportunities at the interface between the physical and life sciences, for example, by integrating nanoelectronic devices with cells and/or tissue to make possible bidirectional communication at the length scales relevant to biological function. In this presentation, I will overview a new paradigm for seamlessly merging electronic arrays with the brain in three-dimensions (3D). First, I will discuss the design considerations of matching structural, mechanical and topological characteristics of neural probes and brain tissue, thus leading to the paradigm of tissue-like mesh electronics that exhibits unprecedented absence of tissue immune response, interpenetration of neurons and neurofilaments through the open mesh electronics structures, and uniquely stable electrophysiology with the capability to track and stably record from the same single neurons and neural circuits for more than a year. Second, I will described a significant elaboration of this new paradigm by exploiting inspiration from biology to create neuron-like electronics that open unique opportunities in seamless and nearly indistinguishable three-dimensional interpenetrating nanoelectronic and neural networks, and moreover, gave opened new directions at the interface between neural probes and regenerative medicine. Third, I will also present a selection of new and exciting opportunities, including using the noninvasive mesh paradigm as an electronic framework that is biochemically-functionalized to allow for controlled and selective manipulation of endogenous cells in live animals, as well as implantation and noninvasive studies of other areas of the central and peripheral nervous systems. I will conclude with discussion of opportunities and challenges, including our goal of and potential for realizing precision electronic medicine in the brain.

****

**Selected References**

1. T.-M. Fu, *et al.*, *Nat. Methods* **13**, 875-882 (2016).
2. G. Hong, *et al.*, *Science* **360**, 1447-1451 (2018).
3. X. Yang, *et al.*, *Nat. Mater.* **18**, 510–517 (2019).
4. G. Hong & C.M. Lieber, *Nat. Rev. Neurosci.* **20**, 330–345 (2019).
5. Y. Zhao, *et al.*, *Nat. Nanotechnol.*, *in press.*