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Nanoelectronics Meets Biology

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Nanoscale materials enable unique opportunities at the interface between the physical and life sciences, and the interface between nanoelectronic devices and biological systems makes possible communication between these two diverse systems at the length scale relevant to biological function. In this presentation, the development of nanowire nanoelectronic devices and their application as powerful tools for the life sciences will be discussed. First, a brief introduction to nanowire nanoelectronic devices as well as comparisons to other electrophysiological tools will be presented to illuminate the unique strengths and opportunities enabled at the nanoscale. Second, illustration of detection capabilities including signal-to-noise and applications for real-time label-free detection of biochemical markers down to the level of single molecules will be described. Third, the use of nanowire nanoelectronics for building interfaces to cells and tissue will be reviewed. Multiplexed measurements made from nanowire devices fabricated on flexible and transparent substrates recording signal propagation across cultured cells, acute tissue slices and intact organs will be illustrated, including quantitative analysis of the high simultaneous spatial and temporal resolution achieved with these nanodevices. Specific examples of subcellular and near point detection of extracellular potential will be used to illustrate the unique capabilities, such as recording localized potential changes due to neuronal activities simultaneously across many length scales, which provide key information for functional neural circuit studies. Last, emerging opportunities for the creation of powerful new probes based on controlled synthesis and/or bottom-up assembly of nanomaterials will be described with an emphasis on nanowire probes demonstrating the first intracellular transistor recordings, and the development of "cyborg" tissue. The prospects for blurring the distinction between nanoelectronic and living systems in the future will be highlighted.