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Editorial

Bioelectricity: From Endogenous Mechanisms to Opportunities in Synthetic Bioengineering

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Developmental Bioelectricity began with the study of ionic phenomena in living forms.[1] In the early days, the focus was less on discrete model systems and more on a broad investigation across the web of life. Especially prescient were workers such as H.S. Burr and E.J. Lund, who performed electrophysiological measurements in a very wide range of organisms undergoing processes such as morphogenesis, regeneration, and cancer.[2]

Since then, workers in bioelectricity have sought to combine the wealth of data and biological diversity with the insights that can be gained by a focused application of ''high'' technologies for tracking and manipulating bioelectric states, such as genetically encoded voltage reporters[3,4] and optogenetic actuators[5] in a few flagship organisms. As always in such novel conceptual studies, and in the spirit of Hodgkin, Huxley, and the squid giant axon, use of model systems is paying dividends.[6]

In recent years, our field has seen many important advances,[6] as new tools and mechanistic investigations continue to form a synthesis between bioelectrical signaling and the biochemical and biomechanical pathways. Notable examples include the regulation of Hedgehog signaling through membrane potential,[7] the control of membrane potential of cells by substratum stiffness[8] and geometry,[9] and transdifferentiation of endothelial cell progenitors.[10] New endogenous roles have been characterized, including the role of proton fluxes in neural induction in the frog Xenopus laevis[11] and orientation of feathers in chicken embryo skin.[12]

An important opportunity for the future of the field concerns its application in synthetic biology.[13] Although most toolkits for cell engineering today focus on metabolic and transcriptional circuits, there is a huge opportunity of taking what has been learned about bioelectrics in endogenous roles[14] and exploiting it in constructing novel multicellular creations.[15] This ranges from optogenetic control of living organisms as a kind of biorobotics[16] to the study of bioelectric signaling in organoids, assembloids, and organs-on-a-chip[17] to the future use of bioelectric circuits to control morphogenesis and physiological signaling in networks of prokaryotic[18,19] and eukaryotic[20] cells. The unique features of bioelectric signaling as a medium for computation and coordination across tissues promise many applications in synthetic and biomedical contexts.

We invite workers in all of these fields to use our journal as inspiration and a source of ideas and expert contacts for novel collaborative projects in the expanding space of bioelectricity—science, engineering, including synthetic bioengineering, and medicine.

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