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Synthetic electrophysiology: optically controlled oscillators in an engineered bioelectric tissue HAROLD MCNAMARA, HONGKANG ZHANG, CHRISTOPHER WERLEY, Harvard University, ADAM COHEN, Harvard University and HHMI — Multicellular electrical dynamics underlie crucial physiological functions, but the complexity of natural bioelectricity can obscure the relation of individual components (proteins, cells) to emergent system-level dynamics. Here we introduce optopatch-spiking HEK(OS-HEK) tissue, a minimal synthetic bioelectric tissue with 4 transgenic components that supports optical initiation of propagating electrical waves as well direct optical voltage readout. In conjunction with a home-built inverted microscope capable of patterned illumination, we use this tissue to probe the biophysical attributes of this excitable bioelectric medium, including dispersion relations, curvature-dependent wavefront propagation, electrotonic coupling, and effects of boundaries. We then used chemical patterning to define cellular circuits that support controllable oscillations and which retain memory for more than 2 hours (corresponding to 10^4 oscillations), constituting a substrate for binary bioelectric data storage. Finally, we use optical patterning of boundary conditions in a physically homogeneous tissue to design dynamically reconfigurable oscillators.

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