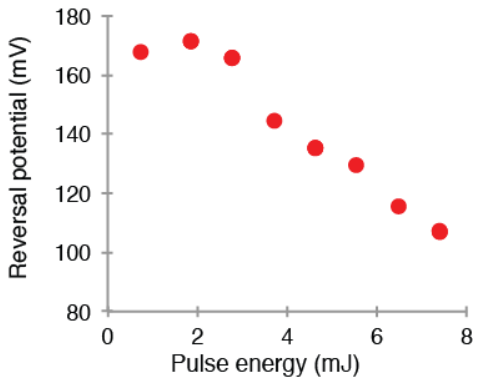
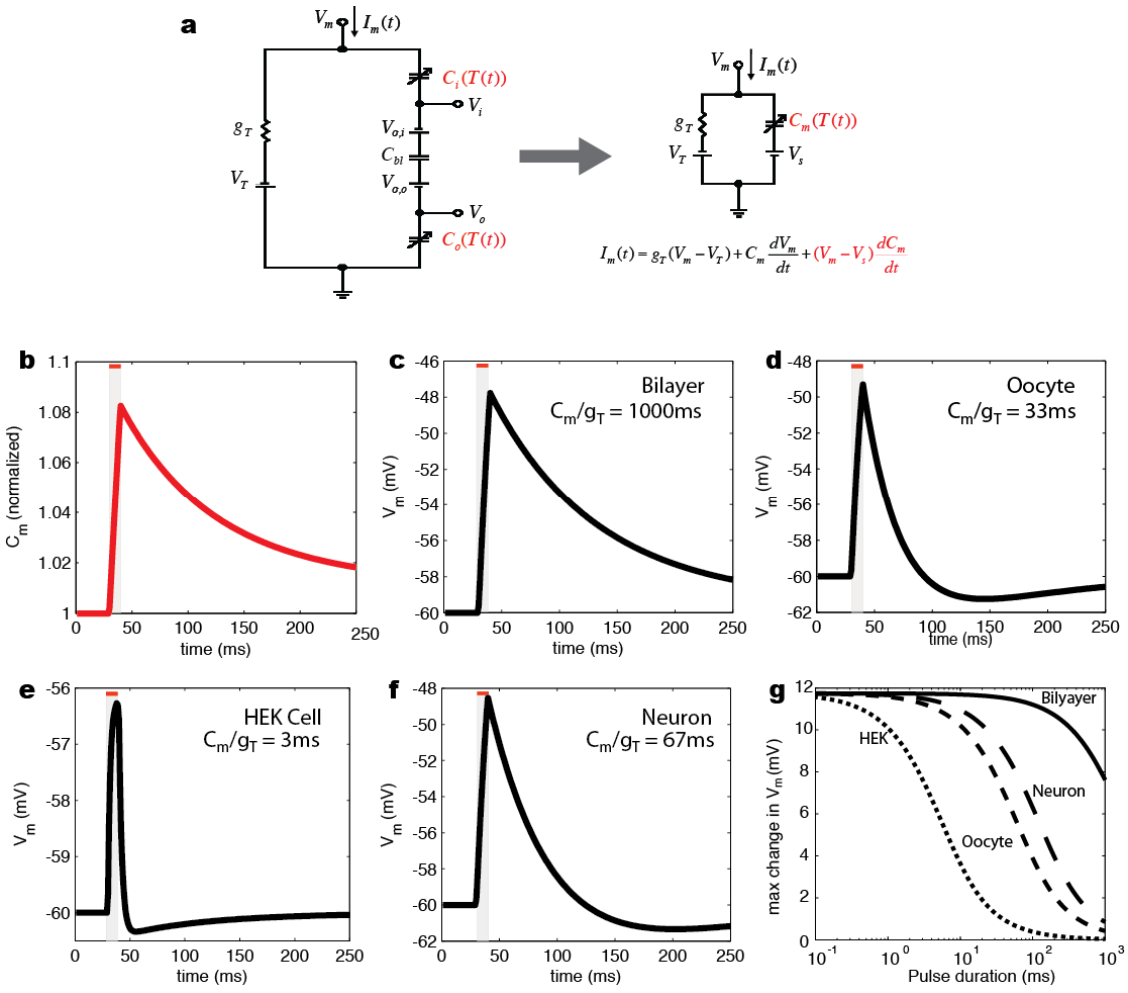
**SUPPLEMENTARY INFORMATION**

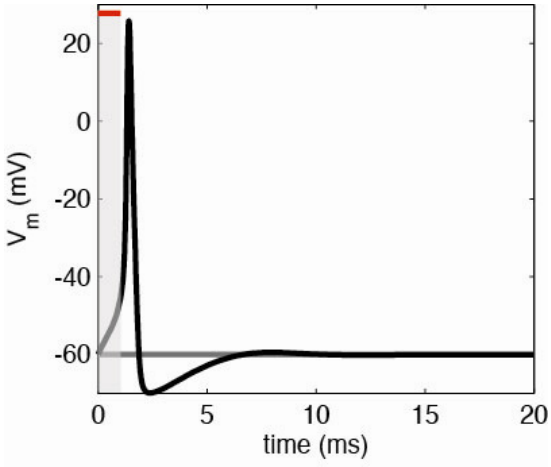



**Supplementary Figure S1. Pulses >3mJ reduce membrane resistance in HEK cells**. Reversal potentials in a representative cell for IR-induced currents with laser pulses of 0.74 to 7.4 mJ. Potentials closer to the cell's zero-current holding potential indicate a reduced membrane resistance. Each point is a single measurement based on Q-V curve.

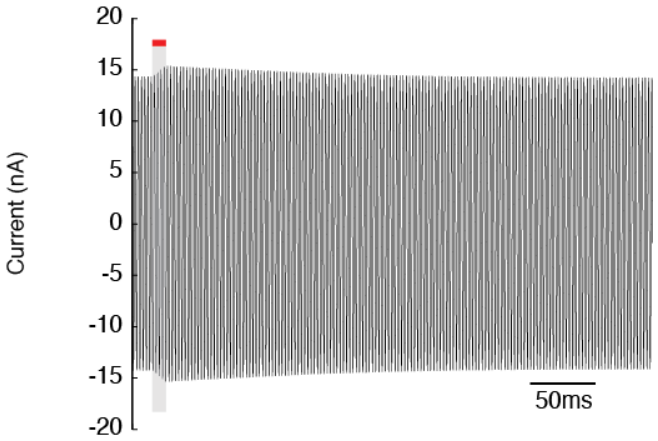



**Supplementary Figure S2. Circuit analysis of the impact of IR-induced changes in capacitance on membrane potential.** (**a**) Left, detailed circuit diagram corresponding to the GCS model of membrane capacitance. $V_T$ and $g_T$ are the Thevenin equivalent potential and conductance of the membrane, respectively. $V_m$ and $I_m$ are the instantaneous intracellular potential and transmembrane current. $C_{bl}$ is the capacitance of the lipid bilayer. $C_i$ and $C_o$ are the temperature-dependent double layer capacitances on the inner and outer side of the membrane. $V_{\sigma,i}$ and $V_{\sigma,o}$ are the potentials due to fixed surface charges on the inner and outer sides of the bilayer. $V_i$ and $V_o$ are the potentials immediately next to the inner and outer surfaces of the membrane. The GCS model solves for $V_i$ and $V_o$, the difference in which can be multiplied by $C_{bl}$ to determine mobile transmembrane charge, the change in which with respect to time was used to model currents in Fig 4. For the purposes of simulating changes in membrane potential resulting from IR-induced changes in capacitance, we used a simplified circuit, right, in which $V_s$ accounts for fixed surface charge asymmetry and $C_m$ represents the aggregate capacitance of the membrane and electrolyte. The temperature dependence of $C_m$ can be obtained from the GCS model as the ratio of mobile transmembrane charge and $V_m$. (this ratio is the same at all values of $V_m$). (**b**) Time course of $C_m$ obtained by applying the GCS model to measured temperature response to a 10ms IR pulse, with parameters representing a 66% greater charge on the outer leaflet of the bilayer. (**d-f**) Simulated

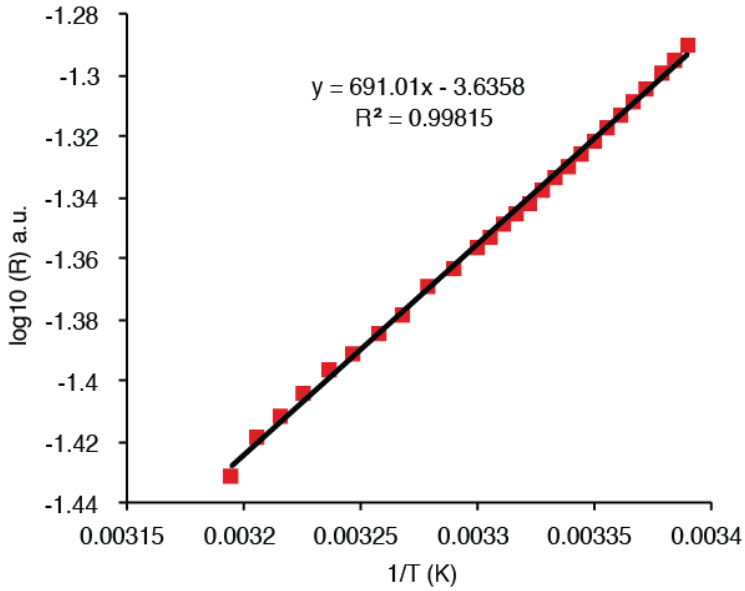
time course of $V_m$ corresponding to the $C_m$ profile in (b). $V_s$ was set to 100mV, representing a scenario in which the outer leaflet carries greater fixed negative charge. $V_T$ was set to -60mV. The value of $g_T$ and initial value of $C_m$ were obtained from literature for two-electrode-clamped oocytes[33], whole-cell-patched HEK cells[34] and neurons[35] *in vivo*. For artificial bilayers we assumed a $C_m/g_T$ ratio of 1000ms. The circuit was simulated numerically based on the equation in (a) with $I_m$ set to zero. Note the voltage undershoots for oocytes and HEK cells, which are consistent with experimental measurements in Fig 1 and Fig 2. (**g**) Linear ramps of $C_m$ to a final 8% increase were used to estimate maximal $V_m$ changes in response to various IR pulse durations in circuits with $C_m/g_T$ ratios representative of bilayers, neurons, oocytes and HEK cells. The lower the $C_m/g_T$ ratio, the shorter the pulse duration needs to be to achieve maximal depolarization. This relationship may help optimize IR stimulation in vivo for various cell types. In panels b-f the red bars and gray shading indicate the timing of the IR laser pulse. All circuit models were implemented in MATLAB.




**Supplementary Figure S3. Simulated action potential response to a 1ms IR pulse causing an 8% increase in capacitance.** We implemented a classical Hodgkin-Huxley squid giant axon model[36] with voltage-dependent potassium, voltage-dependent sodium and leak conductances of 36, 120 and 0.3 mS/cm$^2$. The $C_m$ was increased linearly from a starting value of 1μF/cm$^2$ over 1ms, followed by an exponential decay with a time constant of 100ms. A temperature increase of 15℃ was also applied, tracking the time course of the capacitance, affecting the rate constants of $Na^+$ and $K^+$ conductances with a $Q_{10}$=3. The black trace shows the result of our simulation. Grey trace shows the same simulation, but with only temperature, and no capacitance, change. The red bar and gray shading indicates the timing of the IR laser pulse. Model was implemented in MATLAB.




**Supplementary Figure S4. Raw current response to sinusoidal input in artificial bilayer.** Representative raw current response for a +/-20mV, 400Hz sinusoidal input to a 10ms/7.3mJ IR pulse applied to PE:PC artificial bilayer. Red bar and gray shading indicate timing of the IR laser pulse.




**Supplementary Figure S5. Pipet temperature calibration.** Representative resistance-temperature calibration curve for pipet used to measure the time course of temperature changes induced by IR stimulation. Each point is a single measurement.

## SUPPLEMENTARY REFERENCES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