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This nonspecific cation channel opens when illuminated with blue light, depolarizing the cell [4, 6] to trigger action potentials cells with high temporal precision [5]. Since the initial discovery of ChR2, many modifications have been made to refine the kinetic properties.

For example, ChETA, engineered to address limitations of spike fidelity with ChR2, has faster temporal kinetics and can maintain reliable spike precision up to 200 Hz [7].

Halorhodopsins (NpHR), light-gated chloride pumps activated by yellow light, allow for temporally specific hyperpolarization with single spike precision [8–10].

Archaerhodopsin-3 (Arch), a yellow light-activated outward proton pump, is an increasingly popular tool for light-induced hyperpolarization to inhibit cellular activity. Arch recovers spontaneously from inactivation with a much shorter recovery time than NpHRs [11].

Arch currents continue to increase with increasing light intensity, while NpHRs saturate [11]. The increased light sensitivity of the ArchT variant, along with better membrane targeting, allows for improved neural silencing both at cell bodies and terminals [12].

Many more tools have been engineered with unique optical properties and kinetics. Step-function opsins (SFOs) are bistable ChR2s that can maintain a stable open confirmation to induce a step in membrane potential [13].

Opsins with shifted excitation wavelengths allow for differential cellular activation. Chrimson, a red-shifted opsin, can be used in combination with Chronos, a blue-green activated channel with increased light sensitivity and faster kinetics,

to achieve two-color activation of distinct neuronal populations [14]. Since proton pumps are relatively inefficient compared to channels, moving only one ion across the membrane per photon rather than a steady current of ions, to achieve improved neural silencing,

ChR2 was genetically engineered to conduct chloride ions (Cl^-) to create a depolarizing channel [15]. Further modifications generated step-function control and improved light sensitivity and kinetics, making these useful tools for controlling behavior

in freely moving animals

I will hold my tongue.