Protein ion channels as molecular ratchets. Switchable current modulation in OmpF porin induced by millimolar La3+ ions

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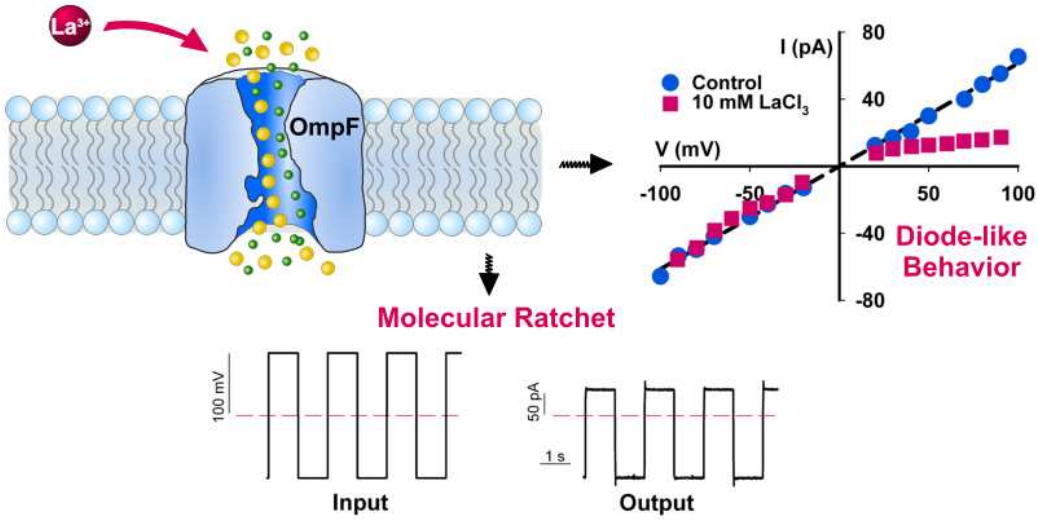

The quest for innovative tunable nanodevices has mainly focused on switches that modulate their properties through engineered conformational changes. We propose here an alternative route that takes advantage of the crucial role that trace elements play in biological nanosystems. To this end, the effect of lanthanum, a high-valence rare-earth metal, known as blocker and modulator of many ion channels, has been studied in a wide, weakly selective biological pore, the bacterial porin OmpF. We show that millimolar concentrations of lanthanum chloride have a dramatic impact on OmpF reducing the conductance for positive but not for negative applied voltages, thus inducing switchable, reversible ion current rectification. By applying an external wave to this lanthanum-induced diode we show that the system can consistently perform like a wave rectifier at considerably higher frequencies than previous nanofluidic diodes. This finding may be the starting point to develop molecular ratchets suitable for a variety of engineering applications