A Mathematical Model of the Lateral Pyloric Cell of the Stomatogastric Ganglion

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Background

The paper *Mathematical Model of an Identified Stomatogastric Ganglion Neuron*, by Frank Buchholtz, Jorge Golowasch, Irving Epstein, and Eve Marder is the second in a three-paper series describing the titular cell in its function and design, mathematical model and dynamical properties, and its response to several neuromodulatory peptides(Golowasch & Marder, 1992; Buchholtz et al, 1992; Golowasch et. al, 1992). In particular, this paper models the six voltage-dependent currents, a Ca^{2+} buffering system, and the membrane capacitance, all of which were experimentally found, and creates a single-compartment, isopotential model of the entire cell. The voltage-dependent currents are as follows: delayed rectifier-like; Ca^{2+}-activated outward; transient A-like; Ca^{2+} inward; inwardly rectifying; and fast tetrodotoxin (TTX)-sensitive Na^{+}, as well as a voltage-independent leak current. The currents are summed and subtracted from an external current to simulate voltage-clamp biological experiments.

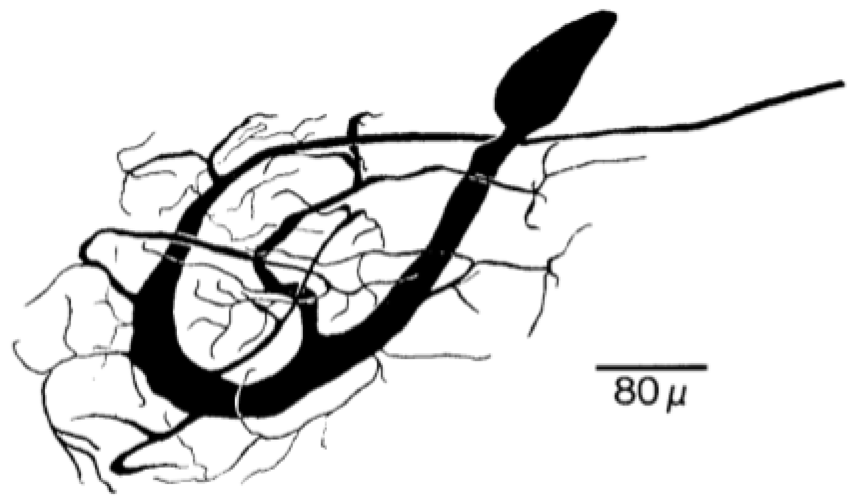

Figure 1. A drawing of the LP cell in the stomatogastric ganglion of the crab *cancer borealis*. Adapted from "Ionic Currents of the Lateral Pyloric Neuron of the Stomatogastric Ganglion of the Crab," by Jorge Golowasch and Eve Marder. February 1992, *Journal of Neurophysiology*, Vol. 67 No. 2

The advantages of studying a mathematical model of the neuron are numerous. Firstly, many methods of studying currents require voltage-clamp experiments, which have a few issues. Researchers using this method assume that synaptic conductances are voltage-independent, an assertion incorrect for a variety of reasons discussed by Anton Chizhov and Dmitry Amahkin in their paper *Method of experimental synaptic conductance estimation: Limitations of the basic approach and extension to voltage-dependent conductances* (Chizhov & Amahkin, 2017). The model also allows researchers to increase or decrease conductance of individual currents, as well as examine currents independently of each other in ways that simply cannot be done experimentally. The model can then be compared against biological data obtained in voltage-clamp experiments to corroborate accuracy.

The authors aimed with the paper to describe the contribution of each current to the overall dynamic properties of the cell. Similarly, we hypothesize that the identified currents can accurately recreate biological data when given a similar stimulus, and then be taken individually to further explain the effect of each current on overall potential despite the relative simplicity of the model.

Significance

The paper is well-cited, both for its biological data (Fox, 2017; DeMaegd, 2018, pg. 16), it's deterministic qualities (Herrera-Valdez, 2012), and its identified currents (Daur et. al, 2012). The stomatogastric ganglion is an important cell in the crab, controlling directly several muscles in the foregut. The LP neuron itself directs multiple connections through the neuropil of the STG, in part affecting motor patterns (Golowasch & Marder, 1992). As stated above, the mathematical model has several advantages over direct biological study in furthering understanding of each current. While this model is relatively simple, its power in recreating biological data accurately lends it value in closer study.

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