

# **HOMEOSTATIC COMPENSATION AND NEUROMODULATION MAINTAIN SYNCHRONIZED MOTOR NEURON ACTIVITY IN THE CRUSTACEAN CARDIAC GANGLION**

Brian J. Lane

Dr. David J. Schulz, Dissertation Supervisor

## **ABSTRACT**

Animals rely on the nervous system to produce appropriate behavior throughout their lives. In sending commands to the musculature for rhythmic motor behaviors such as breathing or walking, neural networks must be stable enough to send a reliable level of drive with the proper temporal coordination. Networks must also be flexible enough to meet changing environmental demands. Network output ultimately arises from the intrinsic excitability of its constituent neurons and the synaptic connections between them. Large Cell motor neurons (LCs) of the crab cardiac ganglion are able to produce highly conserved output from highly variable underlying intrinsic properties. Pharmacologically blocking a subset of  $K^+$  conductances makes LCs hyperexcitable and desynchronizes their activity. Homeostatic compensation restores synchrony and excitability within one hour via two synergistic mechanisms: the membrane properties of each cell is re-tuned to converge on similar voltage activity, and increased conductance of the gap junctions between the cells helps to buffer away differences in their voltage activity. We found that neuromodulation can either cause or prevent desynchronization, depending on its target(s). 5-HT and dopamine both increased LC excitability. 5-HT desynchronized LCs, but dopaminergic modulation prevents desynchronization by directly increasing gap junctional conductance. Finally, we must recognize that LC activity arises not only from their intrinsic properties, but also from their synaptic drive from pacemaker cells. To address how variable this can be from one animal to the next, we analyze the activity of 131 animals taken over approximately 5 years. We use this to address the fundamental question of how variable networks underlying a particular behavior can be across animals.