Seminario

UNIVERSITA`CAMPUS BIO-MEDICO DI ROMA

Unità di ricerca di Fisica non Lineare e Modelli Matematici

Decoding the Worm Brain

Speaker

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Abstract

Part-1 Toward the complete biophysical modeling of the C. elegans nervous system (02/02/2023)

Reverse-engineering a biological brain is the grand challenge in neuroscience which requires a comprehensive understanding of the brain at every level of complexity. If this goal is attainable at all, it probably will first be achieved in the nematode worm Caenorhabditis elegans with only 302 neurons and a complete wiring diagram – the “Connectome”. However, all previous modeling attempts were unable to generate a unifying hypothesis that explained how the worm brain works. One of the critical factors contributing to this failure was the lack of knowledge of the intrinsic biophysical properties of most neuronal cell types in C. elegans. A compelling example is that, for over 30 years, the scientific community has incorrectly assumed that the nervous systems of C. elegans and other nematodes are strictly analog and do not have action potentials required for spike coding. Our recent work identified the first neuronal action potential and spike-coding schemes in C. elegans in olfactory neurons AWA, marking a shift in our understanding of information processing in the C. elegans nervous system to inform future modeling. More recently, we further identified and characterized additional spiking neurons that fire action potentials with different features and waveforms. An emerging picture from these results is that instead of being the outlier organism that does not use the universal language of neuronal action potentials, C. elegans possess a plethora of diverse spiking neurons to implement specific computations. We are currently working toward an “electrophysiome” - the comprehensive electrophysiological characterization of every neuronal class of the entire C. elegans nervous system. It is our hope that integrating the complete electrophysiome and the complete connectome would be a crucial step towards predictive whole-brain modeling in C. elegans.

Part 2: Spiking neural circuit underlying the C. elegans gut-brain ultradian rhythm (06/02/2023)

Rhythmic behaviors governed by internal biological clocks couple physiology to the nervous system in all animals, with periods ranging from milliseconds to a day to years. A particularly interesting and well-studied rhythmic behavior controlled by the gut and the enteric nervous system is the defecation cycle of the nematode worm Caenorhabditis elegans. This rhythmic behavior, also called the defecation motor program (DMP), consists of a series of stereotyped motor sequences activated once every ~45 seconds when there is abundant food. Previous cell ablation studies defined functions for the GABAergic enteric motor neurons called AVL and DVB in the expulsion step of DMP, but specific roles played by each individual neuron remain unclear. Here we identified AVL and DVB as two spiking motor neurons in C. elegans that function in spatial-temporal regulation of the defecation cycle by firing coordinated action potentials. In particular, both AVL and DVB fire all-or-none calcium-mediated action potentials under current-clamp recording. Extraordinarily, AVL fires compound action potentials with a broad upward spike immediately followed by a downward or negative spike. Ion substitution and mutant analysis indicate that the upward spikes are initiated and maintained by multiple voltage-gated calcium channels, and the upside-down spikes are mediated by the repolarization-activated potassium channel EXP-2. Behavioral analysis and live calcium imaging experiments revealed important functions of the coordinated action potential firing in AVL and DVB for the temporal control of the defecation motor program and reliably expulsion behavior. Altogether, our work suggests that C. elegans is now poised to be perhaps the ideal model system to understand how animals choose one form of coding strategy over the other for neuronal computational and behavioral tasks.

CLICCA QUI PER PARTECIPARE ON-LINE

02/02/2023 - Aula R21 - ore 11.00

06/02/2013 - Aula studio B - ore 14

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