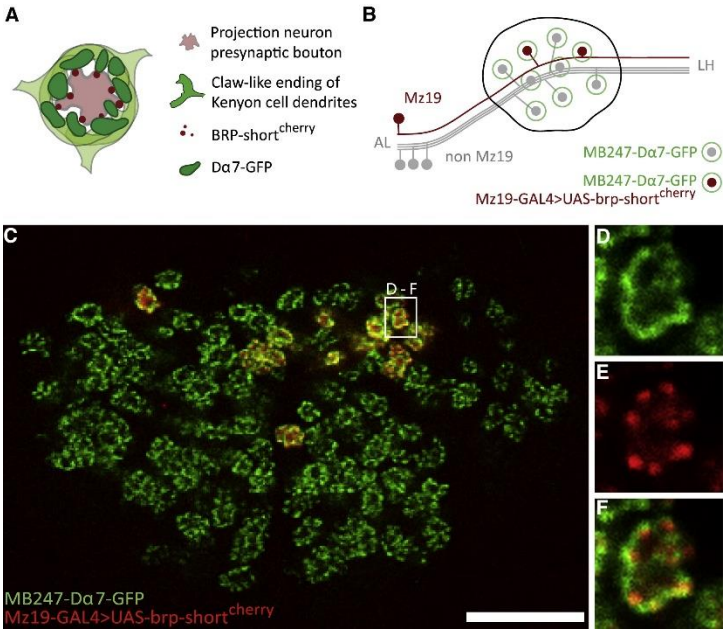
Master's/Bachelor's thesis opportunity in neural development – Investigating spontaneous activity in the Drosophila mushroom body calyx

Our lab is offering an exciting thesis project position exploring the role of spontaneous neural activity during synapse maturation in the Drosophila mushroom body (MB) calyx during metamorphosis. This project is ideal for both bachelors and master students interested in neurodevelopment, synaptogenesis, and *in vivo* imaging techniques.



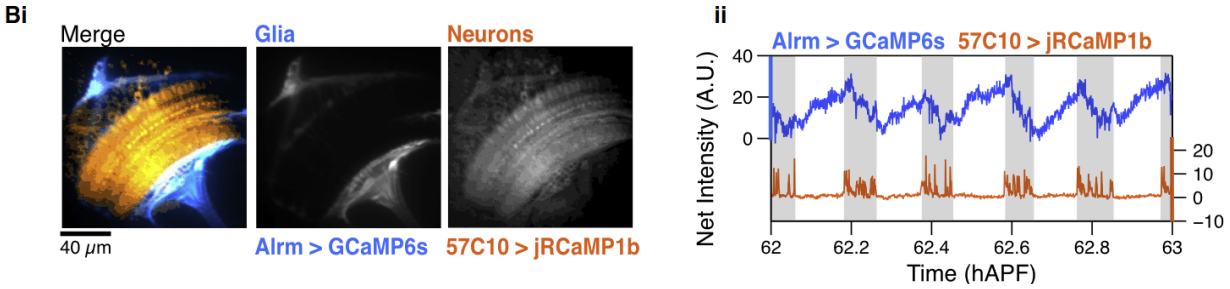
Pre- and Postsynaptic Labeling of Calycal Microglomeruli (A) Schematic of a microglomerulus formed by the axonal bouton of a projection neuron and by the claw-like dendritic endings of multiple Kenyon cells. GFP-tagged Dα7 expressed in a large fraction of Kenyon cells marks the postsynaptic sites, whereas the fluorescently tagged Bruchpilot (BRP)-short protein, expressed within the Mz19-positive subset of projection neurons, labels presynaptic active zones. (B) Schematic representation of the mushroom body calyx. (C-F) Optical sections demonstrating the Dα7-GFP labeling of a large fraction of microglomeruli (green) and the BRP-short^{cherry} labeling of the Mz19-positive subpopulation (red) (Kremer et al., 2010).

Project background

Drosophila melanogaster is a widely used model organism in neuroscience due to its well-characterized neural circuits, genetic accessibility, and evolutionary conservation of fundamental neurobiological processes. The mushroom body (MB) is the central brain region responsible for associative learning and memory that is used as a system for studying neural development. Within the MB, the calyx serves as the primary input region where Kenyon cell (KC) dendrites, the primary MB neuron type, receive synaptic input from projection neurons (PNs). These connections form specialized structures called microglomeruli (Yasuyama et al., 2002, Leiss et al., 2009).

Despite its significance, the precise mechanisms synapse maturation in the MB calyx remains unknown. Understanding when and how mature synapses form is critical for uncovering the principles of synaptic development in this model organism. In the Drosophila visual system, spontaneous, patterned neural activity has been shown to play a role in synaptogenesis, particularly beyond the first 50 hours after puparium formation (APF). During this period, synapse assembly coincides with the upregulation of genes associated with neural activity, along with the emergence of stereotyped bursts of activity (Akin et al., 2019). Additionally, in newly eclosed flies, one subtype of MB Kenyon cells, α'/β', exhibits spontaneous calcium activity mediated by voltage-gated calcium channels, which declines with age. This highlights a potential role for activity-dependent mechanisms in MB development (Leinwand and Scott, 2021). However, it remains unknown whether similar spontaneous activity occurs during synaptogenesis in the MB calyx and whether such activity influences synapse

maturation. This project seeks to fill this knowledge gap by characterizing the timeline of synapse formation in the MB calyx and assessing the role of spontaneous neural activity in this process.



Traces of patterned, stimulus-independent neural activity (PSINA) during the late stages of circuit assembly in the *Drosophila* optic lobe. (Bi) Representative micrograph showing astrocytes expressing GCaMP6s (blue) and pan-neuronal expression of jRCaMP1b (orange). (Bii) Representative trace comparing glial (blue) and neuronal activity from (orange) between 62 and 63 hAPF. Active phases of the neuronal cycles are shaded in gray (Akin et al., 2019)

Research goals: this project aims to:

- Characterize the presence and timeline of spontaneous activity in the MB calyx around 50 hours after puparium formation (APF).
- Investigate whether spontaneous neural activity occurs during this stage and plays a role in synaptogenesis, utilising advanced imaging techniques.

Methods & techniques: the student will gain hands-on experience with:

- ***In vivo* calcium imaging with two-photon microscopy** to monitor spontaneous neural activity.
- **Genetic tools** for manipulating neuronal activity and targeted expression of activity reporters.
- **Fluorescence and confocal microscopy** to analyze synapse formation.
- **Handling and dissection of *Drosophila*,** and all the fundamental skills involved in working with flies.
- **Data analysis of calcium imaging data** using MATLAB and Suite2p.

Candidate profile: we are looking for a motivated Bachelor's/Master's student with:

- A background in neuroscience, molecular biology, or related fields.
- Interest in developmental neurobiology and synaptic physiology.
- Basic experience with microscopy or Drosophila genetics (not required).

Why join us? Our lab offers a dynamic and collaborative research environment and the opportunity to contribute to fundamental discoveries in neural development. This project provides excellent training for students interested in pursuing a PhD in neuroscience and cell biology. If you are interested in this opportunity, please contact us with your CV and a short statement of interest. Also please check out our website https://www.devbiol.rwth-aachen.de/ for more information about the lab. We look forward to hearing from you!

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