Decoding the computational role of adult neurogenesis in hippocampus

https://www.youtube.com/watch?v=Gr-9mPjFb0I&ab_channel=ScienceAnimated

Preferred course of study/expertise of candidate: Neuroscience, Computational biology

Hippocampus - the center for learning and memory, is thought to undergo **adult neurogenesis** to aid with formation of new memories and learning of novel tasks (1). The current state-of-the-art research supports this hypothesis by providing some correlational evidence for 'how' this phenomenon occurs at the cellular level in the dentate gyrus (DG) of the rodent brain. With the help of various studies, we now know about the types of cells generated during adult neurogenesis, length of their maturation cycles, and how they get incorporated into the already-existing neural circuits (2). What the field now needs is to understand 'why' the brain devised these cellular strategies, **effects of the adult-born (a-b) neurons in the DG on the downstream and upstream circuits, and their computational role in various memory processes, and thus get a deeper understanding of various hippocampal memory processes**.

To answer such questions, we will employ ***in-vivo*** **chronic neuroelectrophysiology using tetrodes** (3,4), and read out the electrical signal from the mouse DG, while the animal is freely-behaving and performing various memory tasks. Using the techniques previously developed in the lab (5), we will increase a-b neurons in mice, and further excite or inhibit them, to study the effects of these neurons on various different memory processes.

We are looking for a Ph.D. candidate with a background in Neuroscience/ Physics/ Mathematics/ Computer Science, and who would be interested in the development of computational and statistical analysis for this project. The candidate would also be expected to participate in designing of the experiment, handling and training of mice, surgical implantation and data collection.

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2. Miller SM, Sahay A. Functions of adult-born neurons in hippocampal memory interference and indexing. *Nat Neurosci.* 2019;22(10):1565–75.
3. Moser E, Moser M, McNaughton B. Spatial representation in the hippocampal formation: a history. *Nat Neurosci.* 2017;20(11):1448–64.
4. Purandare C, Dhingra S, Rios R, Vuong C, Nature TT, 2022 undefined. Moving bar of light evokes vectorial spatial selectivity in the immobile rat hippocampus. *Nature.* 2022;602(7897):461–7.
5. Berdugo-Vega G, et al. Increasing neurogenesis refines hippocampal activity rejuvenating navigational learning strategies and contextual memory throughout life. *Nat Commun.* 2020;11(1):1–12.

The role of adult neurogenesis in olfaction

https://www.youtube.com/watch?v=fdyRamKl1wE&ab_channel=TUDresden

Preferred course of study/expertise of candidate: Neuroscience, Cellular and Molecular biology

Olfaction underlies our ability to detect chemicals in the environment allowing us to prime specific memories and emotions, shape perceptions of stress and mood and, hence, directly influence our behaviour. Notably, the olfactory system is exceptional in that it includes Neural Stem Cells (NSC) undergoing adult neurogenesis both at the level of the Olfactory Epithelium (OE) and Olfactory Bulb (OB) within the peripheral and central nervous system, respectively (1,2).

Our group has found that shortening the G1 phase of the cell cycle promotes the expansion of NSC and ultimately increases the number of neurons generated in the mammalian brain (3). More recently, we used this approach to increase neurogenesis in the OB and found not only those supernumerary neurons matured and integrated normally in the olfactory system but also that mice performed better at discriminating between very similar odorants (4).

Moving from the central to the peripheral nervous system, little is known about the role of adult neurogenesis within the OE and how this process influences olfaction. Following our previous approach, the PhD candidate will develop and test the efficacy of increasing NSC expansion and adult neurogenesis in the rodent OE toward improving olfactory function in physiological conditions or rescuing its loss upon disease.

1. Schwob, J.E., et al., *Stem and progenitor cells of the mammalian olfactory epithelium: Taking poietic license.* J Comp Neurol, 2017. **525**(4): p. 1034-1054.
2. Lazarini, F. and P.M. Lledo, *Is adult neurogenesis essential for olfaction?* Trends Neurosci, 2011. **34**(1): p. 20-30.
3. Lange, C., W.B. Huttner, and F. Calegari, *Cdk4/cyclinD1 overexpression in neural stem cells shortens G1, delays neurogenesis, and promotes the generation and expansion of basal progenitors.* Cell Stem Cell, 2009. **5**(3): p. 320-31.
4. Bragado Alonso, S., et al., *An increase in neural stem cells and olfactory bulb adult neurogenesis improves discrimination of highly similar odorants.* EMBO J, 2019. **38**: p. e98791