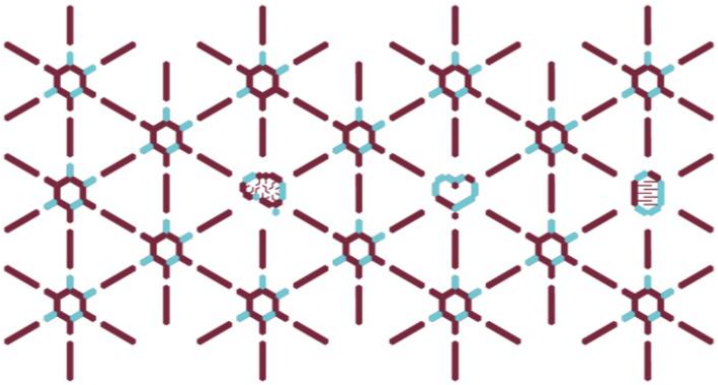
PDBEB DOCTORAL PROGRAM EXPERIMENTAL BIOLOGY AND BIOMEDICINE

IN International Doctoral Program in Integrative Neuroscience



ADVANCED COURSES 2026/2027

Synapse Assembly, Function and Plasticity

2-6 November, 2026

Coordinators:

Ana Luisa Carvalho (CNC-UC/CIBB & FCTUC)

Carlos Duarte (CNC-UC/CIBB & FCTUC)

Paulo Pinheiro (CNC-UC/CIBB & FCTUC)

Location:

CNC Auditorium, 2nd floor, Faculty of Medicine Building, Polo I, University of Coimbra

Aim:

Keywords and broad topics

- Neuronal polarization & synaptogenesis
- Pre- and postsynaptic function
- Hebbian and homeostatic synaptic plasticity
- mRNA Translation and Synaptic Plasticity
- Inhibitory transmission
- Dendritic integration
- Glial regulation of synaptic function
- Neuromodulation
- Synaptopathies

Monday, Nov 2, 2026 – Synapse Formation and Function

9:00-9:15	**Structure of the course; Introduction of students and lecturers**
9:15-10:00	**Principles of neurophysiology – *Paulo Pinheiro (CNC-UC)***
10:00-10:30	**Coffee break**
10:30-11:15	**Establishing neuronal polarity & forming synapses - *Nuno Apóstolo (MIA & CIBB, UC)***
11:15-12:00	**Presynaptic function – *Paulo Pinheiro (CNC-UC)***
12:00-12:45	**Post-synaptic receptor function – *Ana Luisa Carvalho (CNC-UC)***
12:45-14:00	**Lunch Break**
14:00-14:30	**Rethinking Immunofluorescence with Single-Domain Antibodies: From Direct IF to Flexible Multiplexing – *Felipe Opazo (NanoTag,* University Medical Center Göttingen, Germany*)***
15:00-19:00	**Introduction to hands-on projects and protocol preparation**

Tuesday, Nov 3, 2026 – Synaptic Function and Plasticity

9:00-9:45	**GABAergic inhibition – why is it important? – *Joana Lourenço (ICM, France)***
9:45-10:30	**Division of labour of different inhibitory neurons – *Joana Lourenço (ICM, France)***
10:30-11:00	**Coffee break**
11:00-11:45	**Synaptic plasticity: does it really matter? – *Ana Luisa Carvalho (CNC-UC)***
11:45-12:30	**Function and plasticity of inhibitory synapses - *Shiva Tyagarajan (CNC-UC)***
12:30-14:00	**Lunch Break**
14:00-15:00	***Open Seminar by Joana Lourenço: Endocannabinoid-dependent modulation of cortical inhibitory circuits***
15:00-19:00	**Hands-on projects**

Funded by the European Union

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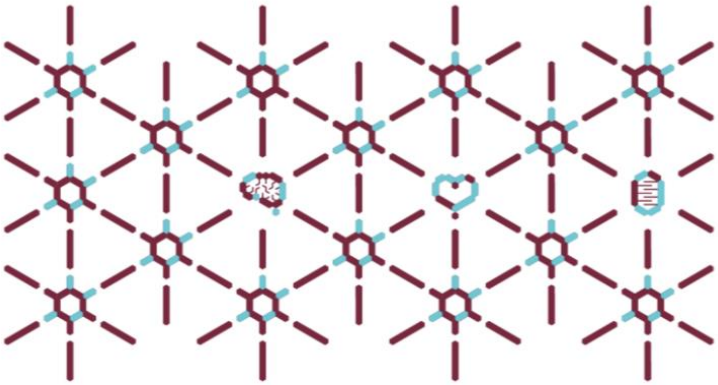

ADVANCED COURSES 2026/2027

Synapse Assembly, Function and Plasticity

5-9 January, 2026

Wednesday, Nov 4, 2026 – Synaptic Regulation

9:00-9:45	Synaptic regulation by neurotrophins – local translation at the synapse – *Carlos Duarte (CNC-UC)*
9:45-10:30	Modulation of synapses by glial cells – *Maria Joana Pinto (i3S, University of Porto & CNC-UC)*
10:30-11:00	Coffee break
11:00-11:45	Neurotrophins in the regulation of fear memories – *Mónica Santos (CNC-UC)*
11:45-12:30	Advanced fluorescence microscopy for Neurosciences – *Joana Ferreira (MIA & CIBB, UC)*
12:30-14:00	Lunch Break
14:00-15:00	Methods to model synaptic function – *Renato Duarte (CNC-UC)*
15:00-19:00	Hands-on projects

Thursday, Nov 5, 2026 – Synaptopathies

9:00-9:45	mRNA translation and synaptic plasticity: molecular mechanisms underlying memory and neuropsychiatric disorders – *Kobi Rosenblum (University of Haifa, Israel)*
9:45-10:30	Synaptic dysfunction in the etiology of neurodevelopmental disorders – *Susana Louros (University of Edinburgh)*
10:30-11:00	Coffee break
11:00-11:45	Synaptic protein turnover in neurodevelopmental disorders – *Susana Louros (University of Edinburgh)*
11:45-12:30	Synaptic regulation in Amyotrophic Lateral Sclerosis – *Ana Rita Quadros (CNC-UC)*
12:30-14:00	Lunch Break
14:00-19:00	Hands-on projects/data analysis

Friday, Nov 6, 2026 – Student Presentations

9:00-10:30	Students presentations
10:30-11:00	Coffee break
11:00-12:30	Students presentations
12:30-14:00	Lunch Break
14:00-15:00	*Open seminar by Kobi Rosenblum*
15:30-17:00	*Social Activity*

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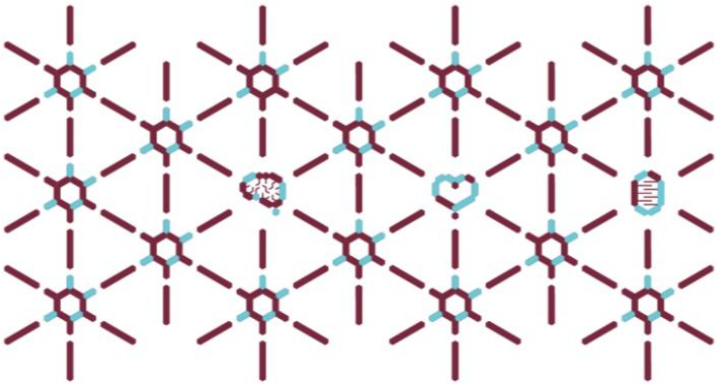

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Synapse Assembly, Function and Plasticity

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Experimental Projects

P1. Studying synaptogenesis by imaging hemi-synapses (Luís Ribeiro (MIA & CIBB, UC))

Protein-protein interactions, like between cell-surface receptors, are pivotal for proper brain function. Establishment of connections between the pre- and the postsynaptic sides of synapses is secured by cell adhesion-proteins (CAMs). Particularly during development of the central nervous system, they are involved in brain wiring and synaptogenesis, leading to the formation of functional neural circuits. In this project, we propose to use co-cultures of HEK cells-expressing functional CAMs to form hemi-synapses in contacting primary neurons. This system will allow the expression of uncharacterized cell surface proteins in HEK cells, to investigate their role in synaptogenesis and to characterize novel protein-protein interactions. The clustering between the expressed cell surface protein and the synaptic marker will be evaluated by immunostaining followed by fluorescent microscopy. Quantification of cluster area and intensity of synaptic clusters onto HEK cells will be performed using the freeware imaging processing software ImageJ. [Ribeiro LF et al. (2019) SorCS1-mediated sorting in dendrites maintains neurexin axonal surface polarization required for synaptic function. PLoS Biol. 17: 1–33]

P2. Fluorescence microscopy to unveil synaptic protein organization (Nuno Beltrão (CNC-UC/CIBB))

Synaptic protein organization can be unveiled using fluorescence microscopy at high resolution, and synaptic markers can be quantified using image quantification tools. These analyses allow for inter-group comparison and evaluation of synapse density and structural properties. In this hands-on project we will use antibodies against synaptic pre- and post-synaptic proteins to evaluate their labeling in mouse cerebellum slices, in control animals and human disease mouse models.

P3. Assessing F-actin dynamics in spines (Débora Serrenho (CNC-UC/CIBB))

Dendritic spines are small dendritic protrusions where most excitatory synapses occur. Spines are highly dynamic compartments with a variety of morphologies, and whose shape is mostly controlled by actin dynamics. Examining spine morphology and actin dynamics in spines can shed light on the mechanisms underlying synaptic function and dysfunction. In cultured neurons, actin dynamics can be studied by performing Fluorescence Recovery After Photobleaching (FRAP) experiments in dendritic spines of neurons expressing fluorescently-tagged actin. With this technique, it is possible to determine the diffusion properties of a given molecule. The time it takes for the fluorescent signal to be re-established upon bleaching, as well as the percentage of recovered fluorescence in the bleached area, will provide information about the dynamics of actin in the chosen spine. In this hands-on session, we will use FRAP to assess actin dynamics in spines of cultured rat cortical neurons expressing both LifeAct-EGFP and PSD95.FingR-RFP (to allow the visualization of postsynaptic sites). Neurons will be incubated with immunoglobulins purified from the plasma of patients with autoimmune encephalitis or healthy individuals, to evaluate how they impact on spine F-actin dynamics. Overall, this experiment will demonstrate how to assess actin dynamics in vitro and the importance of protein diffusion for spine physiology.

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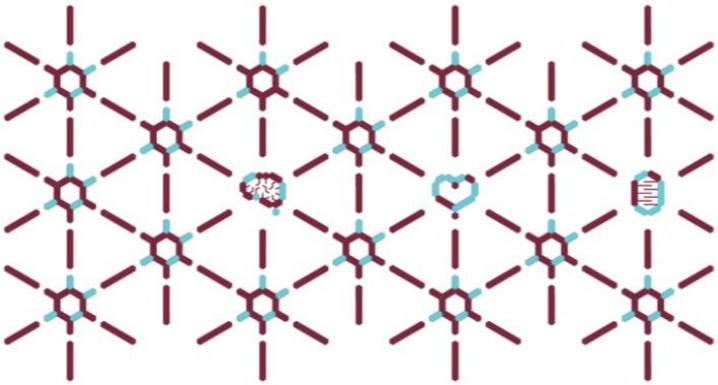

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P4. Evaluating neuronal and network activity in cultured neurons using multielectrode arrays (Miranda Mele (CNC-UC/CIBB))

In vitro neuronal models are an important tool to study the communication of neuronal circuits in health and disease. The measurement of electrical activity from neuronal populations gives information about neuronal network development and organization. In this project students will have the opportunity to use Microelectrode Arrays (MEA) to study neuronal network activity in primary neuronal cultures. Neurons will be cultured in MEA plates on a grid of electrodes. Over time, as the cultures become established, neurons form cohesive networks. Spontaneous firing of neurons, as well as the activity under different protocols of stimulation, will be captured from each electrode on a microsecond timescale using the MEA, providing both temporally and spatially precise data. MEA analysis software will be used to extract the parameters that describe the pattern of neuronal activity, including activity, synchrony, and network oscillations.

P5. Assessing neuronal development through dendritic morphology and Sholl analysis (Rui O. Costa (CNC-UC/CIBB))

Neuronal development involves extensive morphological remodeling, particularly the growth and branching of dendrites, which ultimately determines how neurons integrate synaptic inputs and become incorporated into functional circuits. Alterations in neuronal function are therefore frequently associated with changes in dendritic architecture. In this hands-on project, students will learn how neuronal morphology can be quantitatively assessed using fluorescence microscopy and image-analysis tools. Primary neurons immunolabeled with a somatodendritic marker will be imaged and their dendritic arbors reconstructed using ImageJ/Fiji. Students will then perform Sholl analysis, in which a series of concentric circles centered on the neuronal soma is used to quantify dendritic intersections as a function of distance from the cell body. Additional morphological parameters, including total dendritic length, number of primary dendrites, branch points and terminal branches, will be quantified to provide complementary measures of neuronal complexity. By comparing neurons from different experimental conditions and/or developmental stages, students will explore how quantitative morphological analysis can be used to identify alterations in neuronal development and relate structural changes to potential changes in neuronal function. This approach provides a simple and powerful tool to study neuronal maturation in health and disease.

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