Cajal course on Connectomics: from Micro- to Meso- and Macro-Scales

Miniprojects

Students will gain theoretical and practical experience in state-of-the-art methods and learn about their applicability for addressing timely questions in the field of connectomics through participation in miniprojects. These miniprojects — conducted in groups of three students — are divided into two main themes each lasting nine days. Each participant will observe demonstrations and get hands-on experimental experience in these selected aspects. Participation in both themes is obligatory.

Theme 1 (2-11 October): The first theme will cover approaches that are applied to study functional and/or structural aspects of connectivity in mice using EM- and super-resolution microscopy, multi-electrode recordings and neuronal calcium imaging approaches (two-photon and miniature fluorescence microscope) in behaving animals, viral mono-synaptic connectivity tracing, whole brain clearing and imaging, or by optogenetic manipulation of neuronal projections during behavioural tasks.

Within the mouse part, we will offer 7 practical projects and students are expected to pick one of them. They will evolve around the following methodological approaches:

1. Super-resolution approaches to connectomics (in slices and maybe in vivo)
2. EM block-face scanning microscopy
3. Simultaneous recordings from synaptically connected pairs of genetically targeted cell types, optogenetic stimulation, neuromodulation
4. In vivo multi-electrode recordings from neocortical circuits during a behavioural task
5. Optogenetic probing of defined neuronal populations during a behavioural task
6. Viral connectivity tracing (e.g. mono-trans-synaptic tracing), whole-brain clearing and imaging, and brain-wide connectivity mapping
7. Calcium population imaging in vivo using 2-p and miniature fluorescence microscope during behavioural tasks

Theme 2 (12-21 October): The second part will cover multimodal magnetic resonance imaging methods including structural and functional connectivity measurements using graph analysis approaches, diffusion imaging with microstructural and tractography analysis of the human white matter, fine-detailed post-mortem tissue dissection, and full brain network modeling using The Virtual Brain platform.
For the human theme, the idea is to provide the students with the opportunity to practice all the aspects of macro-connectomic neuroimaging analysis:

- Microstructural features of human brain tissues as revealed by diffusion MRI (Maxime Descoteaux, Sherbrooke, Canada).
- Extracting the structural human connectome with diffusion-weighted whole brain tractography (Michel Thiebaut de Schotten, Paris, France).
- Real blunt dissection of the main white matter pathways of the human brain (Silvio Sarubbo, Trento, Italy).
- Resting-state human functional connectome and network analysis (Sophie Achard, Grenoble, France; Félix Renard, Quimper, France).
- The Virtual Brain, simulate a human brain right on your PC (Demian Battaglia, Marseille, France).