

PSL Master in Life Sciences – M2

Semester S1, 2026-27

UNBIO1-021 Neurophysiology (6 ECTS)

<https://www.edu.bio.ens.psl.eu/spip.php?article100>

1. Short Description of Course

Aims : This course aims at providing a complete theoretical and practical grounding in the electrophysiological techniques underlying modern research in Neurophysiology.

Themes : Neurons are excitable cells that "express" themselves mainly through electrical signals. These signals (membrane potential changes, current flow through ion channels ...) take place on a very fast time scale, of the order of milliseconds. The nature and speed of these signals impose strong constraints on experimental approaches for studying the physiology of neurons. The two disciplines best adapted to the requirements of Neurophysiology are electrophysiology and cellular imaging techniques. This course will focus on electrophysiology.

Maximum class size: 12 students.

The class is taught in: English

Keywords: Neurophysiology | Electrophysiology | Experimental setup | ex-vivo | in-vivo | Patch-clamp | Extracellular recordings | Specific data analysis | Electronics for electrophysiologists

2. Registration

This course is co-organized with the Master BIP of Sorbonne Université. No external students to these two masters can attend and validate the course.

3. Location and Timeline

Locations: Biology Department, 3rd floor - Room 305 & 317, at ENS, 46 rue d'Ulm, Paris.
 Sorbonne Université, campus Pierre et Marie Curie, Room TBA. 1, pl Jussieu, Paris.
 ESPCI. Room TBA. 10, rue Vauquelin, Paris.

At ENS-Biology, building entry with access card only (visitors must use the intercom at the entrance). The classrooms floor is accessible without a badge.

Total duration (in person): 4 weeks +

Homework will consist in preparation of a research project (see below)

For exact dates/time of the class this year, refer to the course website or to "Detailed Schedule and Content" section below

4. Instructors and Contact Information

Primary instructors: Mariano Casado (he/his), casado@biologie.ens.fr
 Régis Lambert (he/his), regis.lambert@sorbonne-universite.fr

Preferred method of contact: 1-email; 2- Moodle

5. Course Communications

Most course communication will use email or the Moodle platform.

Course material will be made available on Moodle or sent by email.

Announcements will be sent by email.

6. Course Prerequisites or Co-requisites

Course prerequisites: Solid grounds on Neuroscience at the molecular, cellular and network levels. Being familiar with the electrical properties of excitable membranes.

Co-requisites: As a major part of the course is based on practical workshops, the future use of the acquired know-how in Experimental Neurophysiology will be appreciated.

7. Course Format, Teaching Methods, Special Activities

During the course, students will use existing experimental facilities at the ENS, ESPCI and SU, but they will also assemble for themselves experimental setups adapted to the different planned experiments. They will perform pilot experiments and analyze data.

The course will be completed with some lectures on theoretical aspects and on the applications of neurophysiology techniques.

In addition, students (in groups of 2-3) will produce a written report of a research project / grant proposal that would make use of the techniques seen during the course. This project will be defended in a presentation in November.

8. Expected Learning Outcomes

Upon completion of the course students will be able to:

- Understand the operational principles of several electrophysiology techniques at use in Neurophysiology research
- Handling some basic electronics for electrophysiologists
- Install an ex-vivo patch-clamp setup from scratch
- Performing ex-vivo patch-clamp recordings
- Analyze datasets specific to ex-vivo and in-vivo electrophysiology
- Elaborate a proper draft of a research project or grant proposal covering three years of work
- Present and defend such project

9. Detailed Schedule and Content

	September 7th	September 8th	September 9th	September 10th	September 11th
Morning	10h ! General presentation / What's hot in Neurophysiology (Casado)	Ion channels (Casado)	Methods in electrophysiology (Casado)	W2	W2
Afternoon	Recalling some notions on electricity (Gendrel) / Guidelines for project (Gendrel)	TD: Recalling some notions on electricity (Gendrel) / Electrical properties of excitable membranes (Casado)	Methods in electrophysiology (Casado) / Thalamus and hippocampus as playfields (Casado)	W2	W2
	September 14th	September 15th	September 16th	September 17th	September 18th
Morning	W1	W1	W1 and protocol writing	S Bagur	Patch-clamp techniques (Lambert)
Afternoon	W1	W1	W1 and protocol writing	W3	W5a (in vitro analysis) (Lambert)
	September 21st	September 22nd	September 23rd	September 24th	September 25th
Morning	W4-T1 / W3	W4-T2 / W3	W5a (in vitro analysis) @SU, <i>salle TBA</i> (Lambert)	W4-T3 / W3	Numerical methods (Ranft) <i>salle 317</i>
Afternoon	W4-T1 / W3	W4-T2 / W3	W3	W4-T3 / W3	Numerical methods (Ranft) <i>salle 317</i>
	September 28th	September 29th	September 30th	October 1st	October 2nd
Morning	W5b (in vivo analysis) @SU <i>salle TBA</i> (Marti)	W5b (in vivo analysis) @SU <i>salle TBA</i> (Léna)	Linking neuronal activity to behaviour (Faure) <i>salle 317</i>		
Afternoon	W5b (in vivo analysis) @SU <i>salle TBA</i> (Marti)	W5b (in vivo analysis) @SU <i>salle TBA</i> (Léna)			Examination (Ens-Bio, <i>salle 317</i>)

•W1. Workshop "Setting up an electrophysiology rig in 3 days" from 9h30.

•W2. Workshop "Analog and digital electronics for electrophysiologists" (2days, Barbour) from 9h30

•W3. Workshop "Patch-clamp experiments in slices" (5days) (V-clamp/C-clamp, spontaneous/evoked, I-V, excitation/inhibition, Casado, Lambert). Focus on cerebellum or thalamus. Morning from 9h30 (2-3 students shadowing slice preparation, Casado). Afternoon experiment from 13h30.

•W4. Workshop "In vivo Neurophysiology" (2days x 2 groups) (Marti) from 13h30. Anesthetized mice. Single Unit / Multiunit. VTA / IPN.

•W5. Workshop "Analyzing electrophysiological data" (3day) from 9h30. W5a. 1 day in vitro data analysis. Synaptic data in V-clamp and C-clamp; V-dep conductances (Lambert). W5b. 2 day in vivo data analysis. *Data preprocessing: data filtering, cluster cutting, stimulation time extraction, creation of matrices exploitable by R, Matlab, Python or Igor* (Marti). Data analysis: PSTH, auto, cross-correlograms, correlating activity and EEG (Léna)

W1, W2, W3: Ens, room 305. W4, W5: SU@Jussieu, room TBA.

W4: 2 teams of 4-5 students (T1, T2)

10. Evaluation and Grading

12 ECTS.

Written examination at the end of the regular schedule of the course.

In addition, students (in groups of 2-3) will produce a written report of a research project / grant proposal that would make use of the techniques seen during the course. Scientific relevance, originality and feasibility will be evaluated. This project will be defended in a presentation in November.

Assessment Categories	Percentage of final grade
Written examination	50%
Written report of a research project	20%
Presentation of the research project	30%
Total	100%

Possible re-take for the written examination. Re-take grading will be linear (x1) for the first 10 points, and corrected by a factor (x0.2) for the following 10 points. Timing for re-takes will be agreed for the convenience of both, the student and the primary instructors.

11. Required or Suggested Resources

Recommended/suggested readings prior to/during/after the course:

- « Ionic channels of excitable membranes », by B. Hille. Edited by Sinauer.
- « Principles of Neural Science », by Kandel, Schwarz & Jessell. Edited by Mc Graw Hill.
- « Neuroscience », by Purves and others. Edited by Sinauer.
- « Physiology of neurons » by Feltz. Edited by Garland.
- « Electronics for electrophysiologists », by B Barbour

12. Absence, Class Participation, Classroom Behavior Policies

Students are expected to arrive in time and attend classes and workshops regularly. They are expected to fully participate in all course activities, including those that involve witnessing animal experimentation. Students should notify the instructor in advance in case of a planned absence, and should otherwise produce a medical certificate. Thoughtful preparation of TDs activities is expected.

To foster a positive learning environment, students and instructors have a shared responsibility. We seek to create a safe, welcoming, and inclusive environment where all of us feel comfortable with each other and where we can challenge ourselves to succeed. To that end, our focus is on the tasks at hand and not on extraneous activities (e.g., texting, chatting, reading a newspaper, making phone calls, web surfing, etc.).

Disclaimer: Information contained in this syllabus may be subject to change with reasonable advance notice, as deemed appropriate by the primary instructor of the course.