Testi in italiano

**Lingua insegnamento**
INGLESE

**Contenuti (Dipl.Sup.)**
The course of Advanced Electrophysiology introduces electrophysiological approaches to understanding brain function. Topics include intracellular (patch-clamp) and extracellular (MEA & EEG) electrophysiological recordings of ion channel, neuron, neuronal network and brain activity. The course covers foundational quantitative tools of data analysis in neuroscience: noise analysis, Markov chains, quantal analysis, correlation and convolution. It comprises frontal lessons (2 CFU - 16 hrs) and practical lessons at the bench and at the computer (1 CFU - 12 hrs).

- Frontal lessons:
  1) Bioelectricity
  2) Recording intracellular electrophysiological signals
  3) Laboratory computer
  4) Analysis of intracellular electrophysiological signals
  5) Single channel recordings
  6) Synaptic physiology
  7) Recording of extracellular electrophysiological signals (MEA & EEG).
  8) Analysis of extracellular electrophysiological signals (MEA & EEG).

- Practical lessons:
  1) patch-clamp in brain slices
  2) MEA recordings
  3) Laboratory computer: analysis of electrophysiological data

**Testi di riferimento**
- Microelectrode Techniques, 2nd edition
# Obiettivi formativi

La obiettivo è equipaggiare gli studenti con i presupposti concettuali e pratici necessari per interpretare, progettare, eseguire e analizzare esperimenti elettrofisiologici.

**D1 - Knowledge and understanding:**
- Raggiungere un comprensione dei fondamenti teorici degli esperimenti elettrofisiologici;
- ottenere familiarità con aspetti pratici e limitazioni tecniche coinvolte;
- acquisire familiarità con le più importanti attrezzature e strumenti usati nelle tecniche elettrofisiologiche e nell'analisi dei dati e dei segnali temporali.

**D2 - Applying knowledge and understanding:**
A fine corso gli studenti saranno in grado di:
- scegliere le più appropriate tecniche elettrofisiologiche per una domanda specifica;
- progettare e eseguire un esperimento di clamping alla cellula;
- progettare e eseguire un esperimento MEA;
- diventare esperti nelle tecniche elettrofisiologiche e nell'analisi dei dati temporali;
- organizzare e presentare dati elettrofisiologici in una figura adatta alla pubblicazione in una rivista scientifica;
- leggere e valutare critica e scientifica che fa uso delle tecniche elettrofisiologiche.

**D3 - Making judgments:**
La capacità di fare giudizi informati verrà sviluppata attraverso l'interazione con i docenti durante le lezioni, nonché durante la preparazione e l'esecuzione dell'esame finale, che richiede al studente di elaborare e comprendere i temi trattati durante il corso.

**D4 - Communication skills:**
Le lezioni saranno date utilizzando il linguaggio scientifico appropriato. Gli studenti saranno incoraggiati a interagire con i docenti e tra di loro per migliorare il proprio vocabolario scientifico, la capacità di formulare domande e di esprimere le proprie idee.

L'esame di verifica inoltre darà agli studenti ulteriori stimoli per migliorare le loro capacità comunicative, dimostrare la capacità di elaborare e comunicare i punti essenziali in modo conciso e efficace.

**D5 - Learning skills:**
La capacità di apprendere sarà stimolata attraverso lo studio e l'applicazione dei concetti presentati nelle lezioni frontali, e sarà valutata attraverso i procedimenti di valutazione descritti sopra. Gli studenti acquisiranno le conoscenze necessarie per capire le tecniche elettrofisiologiche utilizzate per studiare la funzione cerebrale in salute e malattia.

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## Prerequisiti

Gli studenti dovrebbero avere conoscenze fondamentali in biophysics e neurophysiology.

## Metodi didattici

Lezioni, tutorial in gruppi piccoli alla scrivania, progetti di analisi dei dati.
The material used during the lessons will be made available through the moodle platform. Any necessary change in the course modalities due to COVID19 emergency will be published at the Department, Master Programme and Course websites.

Student assessment includes:

a) A homework assignment consisting in the analysis, figure preparation and interpretation of a set of electrophysiological data. Weight in the final score: 60%;
b) Practicum at the electrophysiological setups. Students will be judged for their propensity for experimental work. Weight in the final score: 10%;
c) A 20 min oral examination on the arguments presented during the course. Weight in the final score: 30%.

The final mark will be a weighted average of the part a, b and c. The exam score is given on a thirty-point scale. To pass the exam, the student must achieve a score of 18/30. To attain the highest score (30/30 with honors), the student must demonstrate full mastery in the understanding, analysis and interpretation of electrophysiological data. The examination procedure is explained at the beginning of the course and is also available in the course introduction presentation.

Bioelectricity. Learning objectives:
- To understand how concentration gradients lead to currents (Fick’s first law);
- To understand how charge drift in an electric field leads to currents (Ohm’s law and resistivity).

Recording intracellular electrophysiological signals. Learning objectives:
- To learn how we can inject currents into neurons (e.g. patch-clamp);
- To understand how membrane capacitance and resistance allows neurons to integrate or smooth their inputs over time (RC model);
- To understand the difference between current-camp and voltage-clamp.

Laboratory computer. Learning objectives:
- To understand how a voltage-clap amplifier works;
- To understand signal conditioning (filtering);
- To understand digital data acquisition (Nyquist theorem).

Analysis of intracellular electrophysiological signals. Learning objectives:
- To learn how to analyze voltage-activated currents (Boltzmann equation);
- To understand how we can estimate ion channel properties from macroscopic currents (noise analysis)

Single channel recordings. Learning objectives:
- To learn how we can perform single channel recordings
- To understand how to interpret single channel recordings (Markov chains)

Synaptic physiology. Learning objectives:
- To understand quantal analysis at central synapses;
- To learn advantages and limitations of current electrophysiological methods to study synaptic transmission, comparison and integration with optical and optogenetic approaches

Recording of extracellular electrophysiological signals (MEA & EEG). Learning objectives:
- To understand the origin of extracellular spike waveforms and local field potentials
- To be able to extract spike times as a threshold crossing
- To understand what a peri-stimulus time histogram (PSTH) and a tuning curve are
- To know how to compute the firing rate of a neuron

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### Practical lessons:
1) patch-clamp in brain slices
2) MEA recordings
3) Laboratory computer: analysis of electrophysiological data

Handbook of Neural Activity Measurements.
Romain Brette & Alain Destexhe, Cambridge University Press 2012

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**Obiettivi Agenda 2030 per lo sviluppo sostenibile**

The contents explore topics related to the objectives of the United Nations 2030 Agenda for Sustainable Development. Specifically, N.3 Health and wellbeing and N.4 Education of quality.

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The objective is to equip the students with the essential conceptual and practical skills for interpreting, designing, performing and analyzing electrophysiological experiments.

D1 - Knowledge and understanding:
- Reaching an understanding of the theoretical underpinnings of electrophysiological experiments;
- Gaining familiarity with the practical aspects and technical limitations involved;
- Acquiring familiarity with the most important tools used in electrophysiological and time series data analysis.

D2 - Applying knowledge and understanding:
By the end of the course the students will be able to:
- to choose the most suitable electrophysiological experimental approaches for a given scientific question;
- design and perform a patch-clamp experiment;
- design and perform a MEA experiment;
- become proficient in electrophysiological and time series data analysis;
- organize electrophysiological data in a figure suitable for publication in a scientific journal;
- read critically a scientific paper that makes use of the electrophysiology techniques.

D3 - Making judgments:
The ability to make informed judgments will be developed through the interaction with the lecturers during class time, as well as through the preparation of the final examination, which requires the student to elaborate and comprehend the topics discussed over the course.

D4 - Communication skills:
The lessons will be given using the appropriate scientific language. Students will be encouraged to interact with the lecturers and among themselves to improve their scientific vocabulary, their ability to pose questions and to expose their ideas. The examination will give students further stimuli to improve their communication skills, demonstrate their ability to elaborate the acquired knowledge and communicate the key points in a concise and effective way.

D5 - Learning skills:
The ability to learn will be stimulated by studying and applying the concepts presented during the frontal lessons, and will be assessed through the evaluation procedures described above. The students will acquire the knowledge necessary to understand the electrophysiological techniques used to investigate brain function in health and disease.
Basic knowledge in biophysics and neurophysiology.

Lectures, small group tutorials at the bench, data analysis projects.

The material used during the lessons will be made available through the moodle platform. Any necessary change in the course modalities due to COVID19 emergency will be published at the Department, Master Programme and Course websites.

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Analysis of extracellular electrophysiological signals (MEA & EEG).
Learning objectives:
- To understand time series analysis for spike trains (Poisson processes)
- To be able to measure spike train variability (Fano factor & interspike interval)
- To be able to use convolution, cross-correlation and autocorrelation functions

Practical lessons:
- Functional connectivity assessed by patch-clamp recordings and optogenetics: preparation of and recording from acute prefrontal cortical slices in the whole-cell patch-clamp configuration in combination with structured illumination optogenetic stimulation;
- Cortico-thalamic oscillations assessed by multi-electrode array (MEA) recordings: preparation of and recording from acute cortico-thalamic slices using multi-electrode arrays in combination with pharmacology;
- Laboratory computer: analysis of spontaneous synaptic activity: data preprocessing, event detection, data and statistical analysis, graph preparation, figure preparation using dedicated software (Clampfit, IgorPro, Matlab and GraphPad).

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N.4 Education of quality

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