UNIVERSITÀ DI PISA

DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

Dottorato di Ricerca in Ingegneria dell'Informazione

Doctoral Course

"Current advances in brain organoid science"

Prof. Jens C. Schwamborn

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Short Abstract: Brain organoids have emerged as transformative tools to model human neurodevelopment and neurological disease with unprecedented fidelity. This doctoral-level course explores cutting-edge advances in brain organoid science, covering methodologies for organoid derivation from pluripotent stem cells, including region-specific differentiation protocols and bioengineering approaches to enhance structural and functional complexity. Participants will examine the use of brain organoids in in vitro disease modeling, gaining insights into neurodevelopmental disorders, neurodegeneration, and personalized medicine. A key focus will be on systems biology and multi-omics strategies to decode organoid biology at molecular, cellular, and network levels. The course emphasizes interdisciplinary collaborations, particularly the integration of engineering sciences, such as microfluidics, bioprinting, and computational modeling, to overcome current limitations and propel organoid research into new frontiers.

Course Contents in brief:

- **Generation and Characterization of Brain Organoids:** Explore protocols for deriving brain organoids from pluripotent stem cells and methods to assess their cellular composition, architecture, and functional maturity.
- **Multielectrode Array Measurements – Electronics Meets Biology:** Learn how multielectrode array technology enables recording and analysis of neuronal network activity in organoids, bridging electronic engineering with neuroscience research.
- **In Vitro Disease Modeling with Organoids:** Examine how brain organoids serve as human-relevant models to study neurological diseases, uncover pathomechanisms, and screen therapeutic compounds.
- **Systems Biology and Multi-Omics:** Understand how integrative multi-omics and systems biology approaches reveal molecular networks and dynamic processes within brain organoids.

- **Self-Organization versus Determination – Biology vs Engineering:** Discuss the balance between natural self-organization in organoid development and engineering interventions to guide structure and function toward specific research goals.

Total # of hours of lecture: 20

References:

Lancaster MA, Knoblich JA. *Generation of cerebral organoids from human pluripotent stem cells.* **Nat Protoc.** 2014 Aug;9(10):2329–40.

Kim E et al. *Magnetically reshapable 3D multi-electrode arrays of liquid metals for electrophysiological analysis of brain organoids.* **Nat Commun.** 2025 Feb 27;16:2011.

Gomez-Giro G et al. *Alpha-synuclein pathology spreads in a midbrain-hindbrain assembloid model.* **Adv. Sci.** 2025 Apr.

Fukuda S et al. *Development of bioinformatics and multi-omics analyses in organoids.* **BMB Rep.** 2022;55(2):65–75.

Cederquist GY et al. *Engineering Stem Cell Self-organization to Build Better Organoids.* **Cell Stem Cell.** 2019 Jun;24(6):860–72.

CV of the Teacher

Jens Christian Schwamborn is a Full Professor of Cell Biology at the University of Luxembourg, PI at the LCSB, and Guest Professor for Future Medicine at Nara Medical University. His academic journey began in Chemistry and Biochemistry in Germany, followed by a PhD and postdoctoral work focusing on neurobiology and stem cells. His research centers on developing human in vitro models—especially brain organoids—to study neurodegenerative diseases like Parkinson's disease, where his lab has pioneered midbrain organoid technology. Beyond academia, he is an entrepreneur, co-founding two biotech companies, including OrganoTherapeutics, where he serves as CEO.

Final Exam: Written exam at the last day.

Room and Schedule

Room: *Aula Riunioni del Dipartimento di Ingegneria dell'Informazione, Via G. Caruso 16, Pisa – Ground Floor*

Schedule:

Monday 22, September – 9:00 – 13:00h

Tuesday 23, September – 9:00 – 13:00h

Wednesday 24, September – 9:00 – 13:00h

Thursday 25, September – 9:00 – 13:00h

Friday 26, September – 9:00 – 13:00h