
PhD opportunity - A synergistic approach: Coupling mathematical modeling and quantitative image analysis to understand cell migration and cytoskeletal dynamics during olfactory organ formation

This PhD opportunity is offered through the [BEST Doctoral Programme](#), led by the **University of Toulouse** and co-funded by the **European Union** through **Horizon Europe – Marie Skłodowska-Curie Actions (MSCA COFUND)** and the **Toulouse Initiative for Research's Impact on Society (TIRIS)**. Thanks to this programme, **19 doctoral candidates** will be recruited through an international co-supervision scheme across three major TIRIS thematic pillars : Health & Well-being, Global Changes and Sustainable Transitions. The entire recruitment process will take place between November 2026 and April 2027 and will be managed by the **University of Toulouse (UT)**.

Host Institution	Center for Integrative Biology (CBI), Centre National de la Recherche Scientifique, University of Toulouse, France
Supervisor	Julie Batut - Development & Modeling Organ formation in zebrafish team
Co-supervising institution	University of Zurich, Switzerland
Co-supervisor	Virginie Uhlmann
Contract duration: 36-month	Starting date: September/October 2027

Research topic

The IA-Olf-Mod PhD project, led by Dr J. Batut (CBI, Toulouse) with Prof. V. Uhlmann (University of Zurich), Dr D. Sage (EPFL, Lausanne), and Dr D. Sanchez (IMT, Toulouse), combines genetic manipulation, mathematical modeling, and AI-guided imaging to study cell migration and cytoskeletal dynamics during zebrafish olfactory organ formation. In zebrafish, the olfactory epithelium originates from neural progenitors at 12 hours post fertilization (hpf), with Neurog1-controlled neurogenesis giving rise to early olfactory neurons (EONPs, 12–24 hpf), ciliated olfactory sensory neurons (OSNc), and microvillous olfactory sensory neurons (OSNm, 20–48 hpf). Cxcl12a/Cxcr4b signals orchestrate placode formation and neuronal guidance; however, without proper migration, GnRH neurons cannot reach their target, leading to Kallmann syndrome. To address this biological challenge, the main technical challenge of the project is to process 4D imaging datasets in order to enable the automatic annotation of cell types and to establish links between cell type identity, migration status and cytoskeletal dynamics. The innovation lies in the bidirectional coupling between image analysis and agent-based mathematical models (ABMs) to refine the biological interpretation. To achieve this, the project has set itself three main objectives: 1) to develop open-source tools for multi-scale annotation

and tracking (cell types, cytoskeletal dynamics); 2) to integrate image analysis with ABMs in order to refine biological interpretation; 3) to generate a 3D spatio-temporal atlas of the developing olfactory organ. The methodology involves data acquisition at the CBI, calibration of the ABMs and two two-month stays at EPFL. The expected outcomes, i.e., an open-source pipeline, a calibrated ABM model, and a 3D atlas will enable unraveling the mechanisms of olfactory cell migration associated with Kallmann syndrome, thereby advancing our understanding of developmental mechanisms and pathologies. Finally, the project will help to reduce the workload associated with annotation, speed up the creation of datasets, and broaden access to AI-assisted tools for both the life sciences community and biomedical research.

Keywords: Olfactory organ formation, Quantitative image analysis , Cell migration , Cytoskeletal dynamics , Mathematical modeling , 4D imaging

Context

This project combines image analysis, mathematical modelling and artificial intelligence-guided image analysis to understand the dynamics of the cytoskeleton during olfactory cell migration leading to olfactory organ formation.

International Co-supervision

The IA-Olf-Mod PhD project is an international collaboration between France and Switzerland. Led by Dr Julie Batut (CNRS, Toulouse), it brings together the expertise of Prof. Virginie Uhlmann (University of Zurich), Dr Daniel Sage (EPFL, Lausanne) and Dr David Sanchez (Toulouse). The PhD student, based at CBI Toulouse, will undertake two 2-month research placements at EPFL in Lausanne, benefiting from cross-border access to state-of-the-art facilities and interdisciplinary training in developmental biology, AI-guided imaging data analysis and mathematical modelling.

Experience/Skills required :

- Hold, by 23 November 2026, a Master's degree or an equivalent qualification granting access to doctoral studies in France in Developmental Biology, Cell Biology, Neuroscience, Bioengineering, Computational Biology, Applied Mathematics, Computer Science, or Bioinformatics
- Have not resided in France or carried out your main activity in France for more than 12 months during the 36 months immediately preceding 23 November 2026. Periods of stay as a tourist, refugee, or time spent in national service, are not considered as residency.
- Fluency in English (written and oral) for scientific communication.
- Background: Strong foundation in at least one of the following:
 - o Biological sciences (e.g., developmental biology, cell migration, zebrafish models)
 - o Computational/quantitative sciences (e.g., image analysis, bioinformatics, mathematical modeling)
- Motivation: Passion for interdisciplinary research and a willingness to integrate biological, computational, and mathematical approaches

Technical Skills

- Biology Experience with zebrafish models or other model organisms, cell biology, or developmental processes Familiarity with genetic manipulation, live imaging, or neurodevelopment.

- Microscopy & Imaging Basic knowledge of fluorescence microscopy or live imaging Experience with confocal/light-sheet microscopy, 4D imaging, or ImageJ/Fiji
- Programming in Python, R, or MATLAB for data analysis
- Experience with deep learning (e.g., TensorFlow, PyTorch), Git, or ImageJ macro development
- Image Analysis Familiarity with image processing or quantitative analysis Experience with segmentation algorithms, tracking tools, or machine learning for bioimages
- Mathematical Modeling Basic understanding of computational modeling or dynamical systems Experience with agent-based modeling (ABM), ODE/PDE modeling, or biological simulations
- Data Management Ability to organize and analyze large datasets Experience with cloud storage, version control (GitHub), or FAIR data principles.

Scientific and Soft Skills

- Interdisciplinary Thinking: Ability to integrate biological, computational, and mathematical approaches to solve complex problems
- Experimental Design: Capacity to plan and execute experiments, including controls, reproducibility, and validation
- Critical Analysis: Strong analytical and problem-solving skills to interpret imaging data and model outputs
- Collaboration: Experience or willingness to work in a team with experts from diverse fields (biology, mathematics, imaging)
- Communication: Ability to present research at conferences and write scientific manuscripts
- Adaptability: Willingness to learn new techniques (e.g., advanced microscopy, ABM, deep learning) and adapt to interdisciplinary challenges

Application Process

Call for application - 23 November 2026

Applications must be submitted online through the application platform : edd-projets.utoulouse.fr

Please contact us at isabelle.saves@utoulouse.fr before applying and if you have any questions regarding CBI or the recruitment process. Please use the following email subject line: BEST call – [Supervisor name]

Eligibility check - 24 to 30 November 2026

Written evaluation - 4 December to 15 January 2027

Consolidation of pre-selected projects - 19 January to 19 March 2027

Oral evaluation - 29 March to 4 April 2027

Result - April 2027

Starting date: September/October 2027 (Contract duration: 36 months)

For additional information: <https://doctorat.univ-toulouse.fr/cofund-best>

Contact : best-helpdesk@utoulouse.fr



About the CBI

Located in Toulouse, in the sunny southwestern of France, the [Center for Integrative Biology \(CBI\)](#) is a **fundamental biology research institute** affiliated with the [National Center for Scientific Research \(CNRS\)](#) - the largest public research organization in France - and the University of Toulouse. The institute brings together **47 research groups**.

The CBI aims to understand the mechanisms, dynamics and behaviors of living organisms, to advance knowledge on the current societal challenges. Research at the CBI use multidisciplinary and multi-scale approaches, from isolated molecules to whole organisms and animal societies, applied to numerous model organisms, from bacteria to man.

CBI offers an **international and interdisciplinary research environment**, with access to advanced facilities and opportunities for scientific and career development. The institute benefits from **a collaborative and international scientific culture**, and is committed to promoting equality, diversity and inclusivity.